# CURRENT ORAL HEALTH STATUS AND PRACTICE IN TAIWAN AND THEIR ASSOCIATIONS WITH QUALITY OF LIFE AND TOOTH LOSS

by
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# ABSTRACT

This thesis has three aims 1) to identify current dental hygiene practice and dental health status among Taiwanese population; 2) to study the association between dental hygiene practice, dental health status, and quality of life indicators; and 3) to assess factors associated with tooth loss among Taiwanese population. This study uses a cross-sectional, secondary database from the National Health Interview Survey. The dependent variables are quality of life-indicators and loss of teeth. Independent variables include both personal characteristics and dental related measures. Results of the study indicate most of the participants reported regular teeth brushing at least twice a day, but about 40% of the participants did not visit any dentist in the past year (Study Aim 1). After controlling for known determinants of quality of life including personal factors, oral hygiene behavior, dental service utilization, and self-reported oral health, a significant and positive association was identified between the behavior of daily brushing teeth and all sub-domains of physical and mental health. Good or better dental function was positively associated with better physical and mental health than poor dental function (Study Aim 2). Significant and positive associations were also identified between tooth loss and dental hygiene practice (Study Aim 3). The implications of these findings are that policy makers and health providers should advocate for good oral health practice and ensure adequate access to oral health services for the population. In addition, policy-making regarding oral health should take full consideration of the socioeconomic determinants of health.



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# EXECUTIVE SUMMARY

STUDY AIMS. The study aims of this thesis research are three-fold: 1) to identify current dental hygiene practice and dental health status among Taiwanese population; 2) to study the association between dental hygiene practice, dental health status, and quality of life indicators; and 3) to assess factors associated with tooth loss among Taiwanese population.

CONCEPTUAL FRAMEWORK. The conceptual framework that provides guidance for accomplishing these three study aims was informed by the determinants of health model that focuses on personal characteristics, behavioral characteristics, and health care practices (Shi and Singh 2012), and a systematic literature review of the relevant topics. It consists of the outcomes of interest (which include quality of life indicators as measured by the eight SF-36 quality of life domains and loss of teeth among adults) and four groups of determinants: individuals' personal factors such as demographic, socioeconomic, and lifestyle behavioral characteristics, individuals' oral hygiene behavior, individuals' use of dental services, and individuals' self-assessed dental health status.

RESEARCH HYPOTHESES/QUESTIONS. **Study Aim 1**: Identify current dental hygiene practice and dental health status among Taiwanese population. **Research Question 1:** What is the current dental hygiene practice among Taiwanese population? **Research Question 2:** What is the current dental health status among Taiwanese population? **Study Aim 2**: Study the association between dental hygiene practice, dental health status, and quality of life indicators. **Research Hypothesis 1:** There is a significant and positive association between dental hygiene practice and quality of life after

controlling for known determinants of quality of life. **Research Hypothesis 2:** There is a significant and positive association between dental health status and quality of life after controlling for known determinants of quality of life. **Study Aim 3**: Assess factors associated with tooth loss among Taiwanese population. **Research Hypothesis 3:** There is a significant and positive association between dental hygiene practice and tooth loss after controlling for known determinants of tooth loss. **Research Hypothesis 4:** There is a significant and positive association between dental health status and tooth loss after controlling for known determinants of quality of life.

METHODS. This study is based on a cross-sectional design and secondary data from the National Health Interview Survey provided by the Bureau of Health Promotion, National Health Research Institutes and Food and Drug Administration of the Department of Health, Executive Yuan, Taiwan. The measures used in this study are informed by the conceptual framework that identifies the domains of interest. Two categories of dependent variables are: quality of life-indicators and loss of teeth. The quality-of-life indicators are obtained from the SF-36 questionnaire including eight specific domains: general health, social functioning, emotional well being, physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, and pain. Independent variables include both personal characteristics and dental related measures. Personal characteristics include individuals' sociodemographic characteristics such as age, gender, Body Mass Index, income, education, marital status, disease history, and lifestyle behaviors. Dental related measures include oral hygiene practice measures such as daily frequency of teeth brushing, time of teeth brushing, frequency of using dental floss, frequency of using mouthwash, and whether have dental

scaling every sixth month; dental service use such as whether have dental visit in the last year; and self-reported oral health measures such as number of lost teeth, have dental prosthesis, self-evaluation of dental function, and self-limitation of food choices due to dental function. Both descriptive and multivariate analyses are performed to study the research questions and hypotheses.

RESULTS. This study included 16,634 Taiwanese adults, nearly one-third of whom were 18-29 years old. Most of the participants reported adequate teeth brushing at least twice a day; dental floss, mouthwash, or dental scaling was infrequently reported. About 40% of the participants did not visit a dentist in the past year. As for their self-report oral health status, half of them reported dental prosthesis, and 40% had teeth lost. Most of the participants reported very good, good or fair dental function; 70% never had to limit food choices because of poor dental function. After controlling for known determinants of quality of life, a significant and positive association was identified between the behavior of daily brushing teeth and all sub-domains of physical and mental health. A dental visit occurring in the past year was inversely associated with four subdomains of mental health, suggesting that poor mental health status could weaken one's dental health thus enhancing the need for dental visit. In addition, using dental floss and having dental scaling were positively associated with some of the subdomains of physical health and mental health such as general physical health, general mental health, and vitality. Using mouthwash was not a significant predictor. Good or better dental function was positively associated with better physical and mental health than poor dental function. Also, the more often food choices were limited, the more likely poorer physical and mental health was also reported. However, tooth loss was not found to be significantly associated with

either physical or mental health. Significant and positive associations were identified between tooth loss and dental hygiene practice. Controlling for other factors, those who used dental floss, had dental scaling every six months, or had dental visit in the past year reported fewer number of teeth lost compared to those who did not have one or more of those dental hygiene behaviors. Furthermore, significant associations were identified between tooth loss and dental health status. Controlling for other risk factors, dental prosthesis and limitations in food choices were both significantly associated with tooth loss, while dental function was inversely related to it.

DISCUSSION. Oral health and oral health behaviors such as daily tooth brushing, use of dental floss, regular preventive dental care, and appropriate food choices, are important contributing factors to general health and quality of life, both physically and mentally. Therefore, policy makers and health providers should advocate for good oral health and ensure adequate access to oral health services for the population in order to improve the health status of the general population. Moreover, educational campaigns and other forms of oral health consulting should be in place to promote oral hygiene practice for better oral health, such as brushing teeth at least twice daily. In addition, policy-making regarding oral health should take full consideration of the socioeconomic determinants of health since they are significantly associated with dental health as well as general health status. This calls for advocacy for social policy in addition to health care policy that targets socioeconomic determinants. Our study found that oral health disparities persisted,

and poor oral health was more likely to be identified among people with low socioeconomic status or with more health needs. Additional resources should be allocated to this group in order to enhance oral health and quality of life of the public since the well-being of vulnerable populations is intertwined with that of the general public.

# Chapter 1. INTRODUCTION AND STUDY AIMS

The extent of tooth loss among older adults in Taiwan increases with age; 12.6% of adults aged 65 and older are edentulous and the number of adults needing prostheses increased from 39.7% to 61.3% as age increases (Kuo et al. 2009). Moreover, mental health status worsened in those needing full prostheses, indicating that both oral health and mental health are affected by the need for prostheses. Furthermore, the relationship between prosthetic status and prosthetic needs was shown to be associated with health-related quality of life (Kuo et al. 2009). In another study of the elderly population in Taiwan, the impact of elderly individuals' perceptions of oral health on health-related quality of life was shown to be greater than the impact of their actual clinical oral health status on quality of life (Lee et al. 2007). Most similar studies of oral health and quality of life targeted specific populations such as the elderly (Ostberg and Hall-Lord 2011; Zhao et al. 2011; Chen and Clark 2011a, 2011b), children (Kumar et al. 2011; Rodd et al. 2011; Sanhouri et al. 2010; Atieh 2008), or patients with specific diseases in different geographic settings (Segura et al. 2011; Enger et al. 2011; Luo and McGrath 2008; Okoro et al. 2011). However, little epidemiologic evidence is available to explain the increasing nationwide trend in tooth loss in Taiwan and knowledge of the risk factors for tooth loss is lacking. Furthermore, the impact of an array of oral health-related measures on quality of life has not been measured nationally in adults aged 18 to 64 years.

In 2005, the National Health Interview Survey (2005) was conducted in Taiwan, gathering comprehensive health-related data from a representative sample of the Taiwanese population, including oral health-related factors. A percentage of participants also completed the Short Form Health Survey (SF-36) (Ware and Sherbourne 1992),

which is a multi-purpose, generic short-form health survey with 36 questions in eight domains corresponding to eight health-related quality-of-life concepts: general health, social functioning, emotional well being, physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue and pain. The SF-36 is noted for its usefulness in health outcome studies of specific populations and in differentiating health benefits of various treatments. We theorized that comprehensive data from the two instruments could provide a valid resource for collection and epidemiologic evaluation of oral health-related measures, including tooth loss, and could help explore the relationship of these measures to quality of life among Taiwanese adults.

Nationwide epidemiological evidence is needed to enhance the understanding of the impact of oral health-related measures on adults' quality of life and to determine the risk factors for lost teeth in our older adult population. Such evidence may help develop national programs and policies for dental care and help Taiwan's population to retain healthy natural teeth long-term. Therefore, we aimed to investigate the relationship between quality of life and oral health in Taiwanese adults and to identify risk factors for lost teeth.

The study aims of this thesis research are three-fold: 1) to identify current dental hygiene practice and dental health status among Taiwanese population; 2) to study the association between dental hygiene practice, dental health status, and quality of life indicators; and 3) to assess factors associated with tooth loss among Taiwanese population. Results of this study would not only provide the information on dental hygiene and dental health in Taiwan but also inform policy makers and the practice community of the risk factors associated with tooth loss. The study would also contribute

to the literature regarding the beneficial effect of dental health and dental hygiene practice, in terms of contributing to the quality of life and the general well-being.

# Chapter 2. BACKGROUND AND LITERATURE

This chapter provides the background information and the literature review relevant to the study. Specifically, Taiwan's dental health status will be summarized. As a comparison, the dental health status of the US will also be reviewed. Next, the literature review will focus on the following three aspects: relationship between dental health and general health, the determinants of oral health, and risk factors for tooth loss. The information and studies reviewed will help inform the conceptualization of our proposed investigation.

## 2.1 Taiwan's Dental Health Status

While the oral health situation in Taiwan shares some similarities with the United States, it faces specific problems and has certain strengths of its own. Taiwan adopted a system of national health insurance (NHI) in March 1995, and this new health system also included dental care benefits. While the system originally operated as a fee-for-service payment scheme, in 2008, the dental sector was the first health care realm in the country to adopt global budgeting. Global budgeting is a cost containment measure in which a committee made up of representatives from the NHI bureau, health providers/associations, labor unions, and researchers/other experts all come together to negotiate the overall budget for oral health care each year, which is then distributed to six regions based on population and capped. Dental expenditures per region per year cannot exceed that cap without losing reimbursement from the NHI (Hsueh 2004). This system aims to provide necessary dental care to all citizens while also containing costs that could be incurred from excess usage/procedures and equitably distributing dental resources in

the form of both money and providers. Providers in underserved regions where dental care is used less frequently receive a higher reimbursement per service than a practitioner in an area with high dental service utilization, which may encourage dentists to relocate to these needy areas (Hsueh 2004). Overall, researchers have found that global budgeting on the NHI dental insurance system has led to increased dental utilization due to less out of pocket costs, a decrease in average expenditure per patient, and a more equitable distribution in dental practices and care utilization between different regions (Hsueh 2004). While there was some worry that universal insurance would lead to rising costs as dentists took advantage of newly-insured patients and ordered unnecessary or expensive tests and treatments, it seems that the financing system was able to control costs while still increasing access, although equity is still not absolute.

However, while access should be universal in Taiwan, uptake is still low, and the number of oral health issues continues to be high. A 2005 survey found that only 39.5% of Taiwanese adults reported having a dental visit in the past year (Wang 2012), and even though children are targeted both through NHI coverage and a variety of other oral health initiatives (including a Flouride-Containing Mouth Rinse Program and a Brushing Teeth After Lunch program, both implemented in schools), the rate of caries is still very high (Huang 2007). A 1995-1997 survey of children in the country found that 89.83% of children had at least one cavity by age six, associated with patterns of low tooth brushing, high consumption of sweets, and nighttime bottle feeding (Tsai 2005). In 2001-2002,

another study was done, and found that caries had decreased with the advent of these school-based preventive programs and NHI, although rates were still quite high, with 27.11% of six year olds and 71.27% of 12 year olds needing at least one tooth restoration (Huang 2007).

Additional issues include oral cancer, which is increasing in incidence and mortality. A 2005 study showed that, in Taiwan, increased risk of oral cancer is associated with tobacco use, alcohol use, and areca nut chewing. Studying 1075 adults in five southern villages, the researchers found a 12.7% rate of precancerous lesions or conditions, with far more prevalence among men. Odds ratios for these conditions for smokers, drinkers and chewers (vs. abstainers) were 4.7, 3.6 and 8.4. Additionally, these risk factors work synergistically; a person who does all three will have a 15 fold greater risk of oral health complications than someone who does none (Chung 2005).

Another issue raised in the Taiwanese oral health care system (and important everywhere) is how to best treat the oral health needs of people with disabilities. Patients with disabilities are less likely to be able to maintain their own oral health, and also face a lack of dental providers with proper training and a willingness to treat them, plus a dearth of policies aimed to helping the disabled achieve better oral health. The 2007 estimate held that about 4.4% of the Taiwanese population had some sort of

disability, and more than 90% of disabled people had caries (and only 32% of these teeth had been filled). Greater attention and training will be needed to address this situation (Jeng 2009).

Finally, a 2003 study sought to assess the "Technical quality of root canal treatment in Taiwan" (Chueh 2003). Using two measures (filling length and sealing density), the authors concluded from their 1085 randomly-selected root canal cases that 70% of these procedures were insufficient in at least one measure. This study and other studies have found that better-trained endodontic specialists have a much higher rate of success with this procedure than general practitioners, and the cases treated in teaching hospitals (presumably with more specialized faculty) were of a higher quality than those treated by private practitioners. This shows the need for both more specialized dentists in Taiwan (as there are still only approximately 400 dental graduates a year and, in 2001, 45.49 dentists per 100,000 insured patients, a decline from 1996) and better training for all practitioners (Hsueh 2004, Jeng 2009).

## 2.2 Dental Health Status of the US

Renewed interest in oral health in the United States was sparked in 2000, when the publication of two important documents reported significant failings of the current

health care system to protect oral health and provide care for all citizens. The first publication was the General Accounting Office's April 2000 report, "Dental Disease Is a Chronic Problem Among Low-Income Populations." This research focused on the "growing concern… that low-income and other vulnerable populations continue to have high levels of dental disease" (GAO 2000). Using the 1994-1997 NHANES, the office concluded that dental health issues are highly inequitable; poorer children had 5x as many untreated cavities as high-income children of the same age, and poor people visited the dentist half as many times (on average) as those of higher incomes. Both children and adults were subject to these inequalities, and as oral health is a cumulative process, poor habits and health established in childhood often continues into adulthood. While states do offer some dental care benefits to the poor through dental coverage in Medicaid programs, use of these services is extremely low. Possible reasons for this low utilization include a lack of dental professionals in certain areas (especially rural areas), refusal of some dentists to take Medicaid patients due to low reimbursement rates, and a lack of patient education about the importance of oral health and availability of services.

The second report was "Oral Health in America: A Report of the Surgeon General," which called the high incidence of oral health problems and the lack of subsequent treatment a "silent epidemic," and used the report to outline the significant general health

issues that are connected with oral health and the wide disparities evident in oral health in the US. As summarized, “The major message of this Surgeon General’s report is that oral health is essential to the general health and well-being of all Americans *and* can be achieved by all Americans” (Surgeon General 2000). The report also emphasized the encompassing nature of oral health, which means much more than a lack of cavities, and should be understood to include oral and pharyngeal cancers, birth defects, tissue disorders, gum disease, and a large variety of other conditions. The report summarized the large scope of the current issue: childhood caries are the most common chronic disease in this age group, 5x more common than asthma, with 78% of 17 year olds having at least one; employed adults lose 164 million hours of work per year due to oral health issues, and there are 3x as many adults without dental insurance than without health insurance. Because general health risk factors like smoking, poor diet and excessive alcohol use also contribute to poor oral health, oral health issues can also be addressed through some existing programs and the need for better coordination is great. Additionally, emerging research shows some correlation between some systemic diseases (like diabetes and heart disease) and oral health problems. For all these reasons, it was seen as necessary to improve oral health care in the US by beginning new research and programs to lessen this disease burden. Unfortunately, the issue has often stalled with

implementation; some important treatments and preventive care methods are already available, but are not being used effectively to promote population oral health. For instance, although water fluoridation is known to help prevent cavities, 100 million people in the year 2000 still lived in communities that had not implemented this fairly simple intervention (Allukian 2000). Overall, "Five broad action steps were recommended to promote oral health and eliminate oral health disparities: 1) change perceptions of oral health; 2) overcome barriers by replicating effective programs and proven efforts; 3) build the science base and accelerate science transfer; 4) increase workforce diversity, capacity and flexibility; and 5) increase collaborations" (Mouradian 2009). The report encouraged renewed commitment and led to the inclusion of oral health goals in the Healthy People 2010 objectives, and again in the 2020 objectives as well (HHS 2010).

Since the publication of the Surgeon General's report, some progress has been made, and some initiatives remain stalled. In 2003, the American Academy of Pediatrics passed a policy supporting the involvement of pediatricians in children's oral health issues, but the need for even greater cooperation and coordination is ongoing. In 2010, the Department of Health and Human Services released its Oral Health Initiative, recognizing many of the challenges discussed in the Surgeon General's report had not

been addressed (DHHS 2013). Through this initiative HHS sought to improve coordination among existing programs and introduce new initiatives in order to: 1) emphasize health promotion and disease prevention; 2) increase access to oral care; 3) bolster the oral health workforce; and 4) eliminate disparities in oral health (DHHS 2010). Among the activities the initiative supported were the establishment of dental homes for Head Start children, the provision of cultural competency training for oral professionals, and assessments of ways to improve access to care through Medicaid and Medicare (DHHS 2010). There has been some increase in dental care utilization, although rates are still very low; states now report, on average, 33% of Medicaid eligible children receiving a dental visit as opposed to the previous measure of 27% (Mouradian 2009, Hakim 2012). There are still other significant barriers as well, including a lack of pediatric dentists and public health dental training, a continuing lack of diversity in the dental health work force, a lack of available practitioners in many areas, and continuing lack of insurance among both children and adults (Mouradian 2009, Edelstein 2009). As of 2013, more than 4,500 shortage areas across the United States were designated by the Health Services and Resources Administration (HRSA) as having a shortage of dental providers (HRSA Bureau of Clinician Recruitment and Service 2013). Additionally, rates of caries continued to be high (increasing in some very young age groups and amongst

some minorities), and racial minorities and low-income people continued to experience a disproportionate burden of oral health disease (Tomar 2009, Edelstein 2009, Sabbah 2009) and lowest oral health and preventive dental care utilization (Guarnizo-Herreno 2012). In fact, some of the oral health disparities even worsened in the past decade and new disparities emerged (Flores 2013). Most recently, it was reported in Health, United States: 2012 that 15.6% of children age 6-19 still have untreated cavities, and that only slightly more than 60% of U.S. adults had a dental visit in the past year (CDC). Furthermore, disparities remain with only 41% of adults in 2011 below the federal poverty level (FPL) having a dental visit in the past year, compared to 79% of adults at 400% FPL or more (National Center for Health Statistics 2013). While awareness of oral health issues has risen, the U.S. still lags behind in addressing these important diseases.

## 2.3 Relationship between Dental Health and General Health

Research from other parts of the world shows an integral relationship between oral health and systemic health (Department of Health and Human Services 2000) and between oral health-related variables and quality of life (Brennan et al. 2008).

Studies have shown oral health to be a component of quality of life through its association with depression and anxiety (Okoro et al. 2011), less satisfaction with life

(Ware et al. 1993; Lee et al. 2007), and various systemic conditions such as cardiovascular disease (Segura et al. 2011) and Sjögrens syndrome (Enger et al. 2011). Oral health factors, including tooth loss and periodontal disease, were significantly related to quality of life (Ng and Leung 2006). Mental health scores decreased in subjects with full prostheses compared to those not needing any prostheses, suggesting that providing prostheses not only serves oral health needs but also mental-health related quality of life (Kuo et al. 2009). Jones et al. demonstrated that oral health-related quality of life was significantly associated with mental and physical component summary scales of the SF-36 in veterans whose health and function were compromised (Jones et al. 2006). Similarly, in Japan, an investigation of general and oral health status of dental patients showed meaningful correlations between the two, as physical symptoms, emotional elements and esthetic expectations of oral health status influenced oral health-related quality of life (Shimada et al. 2005). Interestingly, dental fear and discomfort showed no significant correlations with SF-36 subscales in that study. Another important aspect in some studies was individuals' perceptions of their own oral health. Lee et al. (2007) divided oral health status into clinical disease and elderly patients' subjective feelings, with the number of natural teeth treated as the clinical issue; while gender, education level, frequency of social interaction, and general satisfaction with life affected quality of

life, the individuals' perception of their own oral health status had greater impact on their quality of life (Lee et al. 2007).

Oral health and general health are regarded as being highly linked for a variety of reasons. First, oral health is seen as a major contributor to quality of life issues. Tooth loss led to reduced quality of life in several domains; poor oral health can lead to disability and impairment, both in physical realms (being unable to speak or eat) or social/emotional areas (embarrassment and depression) (Allen 2003; Gerritsen 2010). Oral health is associated with birth outcomes, cardiovascular diseases, and respiratory diseases (Albert 2011; Blaizot 2011; Bansal 2013, IOM 2011). Moreover, dental diseases could lead to great economic burden for individuals, families, communities and health care systems (Casamassimo 2009; IOM 2011). However, because these oral health issues are rarely life-threatening, they often receive little attention or funding. In fact, oral health has been separated from general health for a long time (IOM 2011). Additionally, while more advanced treatments are becoming available, the low status of oral health issues in health policy can leave the cost of these important treatments out of the reach of many, creating inequality as well (Allen 2003).

However, many oral health experts argue that "Oral health affects general health by causing considerable pain and suffering and by changing what people eat, their speech

and their quality of life and well-being…Oral health disease is the most common of the chronic disease and is an important public health problem because of its prevalence, impact on individuals and society, and expense of the treatments" (Sheiham 2005). The myriad effects of poor oral health can be illustrated by how children, from a young age, experience how "Oral health affects people physically and psychologically and influences how they grow, enjoy life, look, speak, chew, taste food and socialize, as well as their feelings of social well-being" (Sheiham 2005). Specifically, children with poor oral health and caries often have pain and discomfort, and can have infections (sometimes deadly), disruptions to sleep, eating or school, can face significant costs for treatment, and may have changed habits leading to poor nutrition, growth and weight gain. These risks are particularly troubling given that 90% of children reported some kind of oral health impact in one study (Sheiham 2005), and the more severe the oral health diseases are, the more negative impact it has on general health and quality of life (Martins-Junior 2013). One dental health survey of preschool children in Hong Kong also revealed that besides the impact mentioned above, parents and families were also affected emotionally by feeling 'upset' or 'guilty' (Wong 2011). A study of Filipino children found that those having untreated dental decay were at an increased risk for having a below normal Body Mass Index, which may be a determinant of poor child development (Benzian 2011). In

addition, oral health diseases can also impact quality of life of the middle-aged. One study conducted in Australia among people between 45 and 54 years old showed that tooth loss and chewing ability were related to quality of life and general health (Brennan 2008). The elderly are also at risk of poor oral health affecting their overall quality of life and general health; many risks for oral diseases are associated with increasing age, including declines in mental health (dementia can lessen one's ability to perform proper oral self-care, and depression has been shown to be associated with an increased risk of tooth loss and pain), dry mouth (also called xerostomia, often caused by multiple medication and can affect chewing, speaking and swallowing, as well as overall comfort), declining nutrition/weight loss (can be an effect of poor oral health conditions and also can cause additional oral health issues), and a variety of other risks (Kandelman 2008; de Andrade 2013). Additionally, Benyamini et al. also found that the connection between self-rated oral health and self-rated general health to quality of life is particularly strong in the elderly (Benyamini 2003). Interviewing 850 retirement community residents, they found that self-rated health and self-rated oral health were both significant factors in self-esteem and life satisfaction, and that self-rated oral health had a unique role in these calculations not fully explained by self-rated general health. Therefore, the researchers recommend that general care practitioners need to pay more attention to the contribution

of oral health to general health, particularly in elderly patients (Benyamini 2003).

In contrast, a similar study was conducted amongst 118 college freshmen, who were asked to rate their oral health and its effect on their quality of life, but the results indicated that oral health in this population had less effect on overall QoL. The population still reported a moderate amount of oral health issues ("caries lesions (16%), gingival problems (18%), ulcerations (21%), problems with eating and drinking (20%), and discoloration of the teeth (21%)"), but overall majority (more than 75%) rated their oral health and general health as good or very good. While their self-reported oral health status was correlated with their oral health quality of life score, it was not associated with their general health quality of life score (Kieffer 2008). While oral health undoubtedly can have quality of life impacts, these impacts are logically less in generally healthy people.

A second issue in the relation of oral health and general health is the acknowledgement of common risk factors that contribute to both oral and other diseases; "As for the major chronic diseases, socioenvironmental factors are distal causes of oral disease, moreover, a core group of modifiable risk factors is common to many chronic diseases and injuries, and most oral diseases. These common risk factors are preventable as they relate to lifestyles, such as dietary habits, use of tobacco and excessive

consumption of alcohol, and the standard of hygiene" (Petersen 2009). This new consideration of distal factors leading to increased risk of both oral and other chronic conditions is fairly new; additionally, the common risk factor approach also brings to oral health a new focus on social determinants of health. As Shieham and Watt criticize, oral health has often ignored social determinants in favor of a narrower, individual and behavioral approach: "Avoiding the need for developing effective social policies for health in favour of a concentration on problems of individual health related behaviour is not only an oversimplification, but an evasion of responsibility. Concentration on lifestyle often obscures broader determinants of health" (Shieham 2000). The common risk approach seeks to find a more holistic view of oral and general health, for individual and social determinants contribute to health, and modification must take place on multiple levels. While these modifications can be complicated and daunting, "The key concept underlying the integrated common risk approach is that promoting general health by controlling a small number of risk factors may have a major impact on a large number of diseases at a lower cost, greater efficiency and effectiveness than disease specific approaches" (Ibid). Therefore, the authors believe that measures meant to address major risk factors like smoking, poor diets (high in saturated fat and refined sugars, low in fruit and vegetables), uncontrolled stress, alcohol use, physical environmental issues, trauma,

and a lack of physical activity will positively impact oral and general health. In fact, the World Health Organization includes several of these approaches in their priority action areas for the improvement of oral health worldwide, along with improving fluoridation, promotion of oral health from a young age (especially using schools), promoting oral health among the elderly, addressing issues of HIV/AIDS and oral health, and improving research, evidence, goals and information systems in the area (Petersen 2008).

The final issue today in the relationship between oral and general health is the emerging evidence of a possible link between oral disease and systemic disease. The most established possible connections are between chronic periodontitis and heart disease and diabetes (Williams 2008). In addition, a growing body of research has begun to explore the relationship of chronic periodontitis with dementia and Alzheimer's disease (Noble 2013). While these associations are far from proven, there are indications that an association exists.

Studies have found that common oral pathogens can be found in the arterial plaques of heart disease patients, and that oral disease can also lead to increased inflammation that may also contribute to heart problems (such as C-reactive protein, which evidence indicates may increase vascular risk). Additionally, severe periodontitis can cause changes in blood pressure and cholesterol, both of which are known

contributors to cardiovascular disease. While the authors acknowledge a lack of prospective studies necessary to validate these associations, one study concludes that that the data "suggests an association between periodontal disease and an increased risk of cardiovascular disease" (Williams 2008). Moreover, according to a study in Taiwan based on a nationally representative database, tooth scaling has been found to be associated with a lower risk of myocardial infarction, stroke, and other cardiovascular events (Chen 2012). However, the association between oral health and systemic diseases has been under criticism as it "separates the mouth from the rest of the body" (Noqueira-filho 2011). In other words, one should not simply assume that diseases in the mouth "would not be expected to have effects elsewhere in the body" (Noqueira-filho 2011). Furthermore, it has been noted that periodontal disease and cardiovascular disease share similar risk factors, which may be the underlying causative relationship instead of periodontal disease itself (Lockhart et al. 2012).

The second possible connection, between oral health issues and diabetes, is hypothesized to be bi-directional in that periodontal disease is a complication of diabetes, but that it also contributes to poor metabolic control of diabetes (Grossi 1998). A number of small studies thus far have found that better oral hygiene can reduce dental plaque and lead to better blood glucose control for Type 2 diabetes patients, and that poorly

controlled diabetes can increase the risk for periodontal disease (Williams 2008). In a 2013 review of current literature similar findings were found supporting a relationship among individuals with periodontal disease with poorer glycemic control, a greater risk for diabetes-related complications, and a greater risk of developing diabetes (Borgnakke 2013). However, this association between periodontal disease and diabetes is also far from well-established as a majority of findings are the result of observation studies, and must be the subject of future studies to determine a potential causal relationship.

In recent years increased attention has focused on the relationship between periodontal disease and cognitive impairment, especially in that of dementia and Alzheimer's Disease (AD). Examination of a large national study in the United States revealed that periodontitis was significantly associated with poor delayed verbal recall and impaired subtraction, two indicators of reduced cognitive function in older adults (Noble 2009). While the direction of the relationship between poor dental health and dementia is still unclear, many studies have found an association in need of further exploration (Iacopino 2009). It is hypothesized that the inflammation caused by periodontal disease is a modifiable risk factor for the development of late onset of sporadic AD (Kramer 2008). The biological mechanisms of the relationship between periodontal disease and cognitive impairment have yet to be determined and should be

the focus of future studies.

In addition to the relationship with the systemic diseases discussed above, studies have shown that poor oral health could be a contributing factor for severe consequences among patients with chronic kidney diseases and chronic obstructive pulmonary disease (COPD), especially among the elderly because these patients are at higher risk of inflammation, infections, and atherosclerotic complications (Akar 2011; Kshirsagar 2009). Overall, it is highly evident that oral health can have great impacts on general health, although the two are not the same. The effects of oral health can be modified by age, health status, social determinants, and pre-existing conditions. Still, good oral health is also likely to have positive effects, both of its own merit and on other domains of health.

## 2.4 The Determinants of Dental Health

Today, the overall consensus indicates that oral health is deeply influenced by the social determinants acting on an individual's life. This new explanatory framework differs remarkably from the prior view of oral health being determined primarily by individual behaviors, and has emerged in conjunction with the renewed focus on social determinants of general health. Some of this shift has occurred due to the failures of oral

health improvement up to this point; “Despite significant overall improvements in oral health in recent decades across the developed world, social inequalities in oral health have remained. Even in countries with well-developed dental health care systems, and where community water fluoridation programmes exist, oral health inequalities, although less marked, still persist” (Watt 2006). Previous interventions had aimed to change individual behavior through targeted measures aimed at the highest-risk population; while these efforts to shift the distribution of oral health treatment from curative measures to preventive programs was well-intentioned, they still ignored the determinants of poor oral health and have led to little sustained improvement (Watt 2005). Now, because the technological, clinical and political advancements and changes over the past 30 years have not eliminated oral health disparities, many researchers feel it is time to move in a new direction.

A 2005 study conducted in Australia explicitly explored this link between behavioral traits and oral health. As stated, “Based on the former relationship [health behaviors and oral health outcomes], virtually all policy makers recognize the benefits of promoting healthy behaviours in individuals and providing adequate access to healthcare services to the population” (Sanders 2005). This health behavior view does recognize that health inequalities exist and are largely correlated with socioeconomic position, but maintains

that behavior is still the primary mediating factor; this "cultural behavioral" view, first laid out in the 1980 Black Report from Britain, hypothesizes that socioeconomic status drives health decision making, and that people from lower SES are more likely to take risks that lead to poor health outcomes than are people from a higher SES (Sanders 2005). This hypothesis has greatly driven oral health policy to this point, leading some researchers to conclude that "the dominant preventive approach in dentistry, i.e. narrowly focusing on changing the behaviours of high-risk individuals, has failed to effectively reduce oral health inequalities, and may indeed have increased the oral health equity gap" (Watt 2006). Sanders et al. acknowledge that this behavioral-oral health relationship is plausible, but contend that "The hypothesis that the poor oral health of poor people is explained by poor behaviour, although compelling, has been widely accepted with very little testing" (Sanders 2005). Their study, based on a self-completed health questionnaire addressing missing teeth, oral health impact on daily life, and self-reported dental behaviors from 3678 adults, indicated that socioeconomic status does influence oral health, but controlling for dental self-care did not eliminate inequalities between people of different SES. If health behavior is indeed such a mediating factor in the SES-oral health relationship, this analysis should have found similar oral health outcomes amongst people of equitable dental care habits, regardless of SES. Instead, they found that while

dental care does play a part in oral health, it still cannot overcome the negative effects of low socioeconomic position on oral health outcomes. This study gives great credence to the inclusion of social determinants of oral health in policy making and resource division, for its results indicate that programs aimed at changing individual behavior (encouraging better home oral care amongst children, reducing barriers to dental visits, etc.) will still be unable to overcome socioeconomic inequality.

Another study conducted in the United States using the 1988-1994 NHANES data reached similar conclusions; individual health behaviors are associated with socioeconomic status. Even when controlling for behavior, the inequality in oral health outcomes by SES does not disappear (Sabbah 2008). By the mid-2000s, oral health experts concluded "It is increasingly recognized that this approach [behavioral intervention] alone will not be effective in achieving sustainable oral health improvements across the population, nor in reducing the oral health equity gap" (Watt 2006).

Therefore, significant attention has turned to more "upstream" determinants of health, and research has begun to look at how these broader factors may influence oral health as well as general health. A 2006 paper on the social determinants of oral health identifies this research topic: "Social determinants of health refer to both specific features

of and pathways by which societal (including cultural) conditions affect health and well-being" (Patrick 2006). These determinants can be influenced by social and cultural factors that are often modifiable through policies and programs: for example, "income, education, social capital, occupation, community structure, social support, availability of health services, and larger forces such as structural inequality, cultural beliefs and attitudes, and legal channels" (Patrick 2006). A major inequality in the United States is dental insurance; many Americans do not have coverage for oral health visits and procedures through a private plan, and the public system for providing such services is inadequately funded and does not meet the country's need. This lack of insurance coverage then restricts the availability of important preventive oral health techniques (as most people without insurance do not have the financial means to receive dental care until there is a large problem) to a large sector of the population, stratifying people by their possession or lack of dental insurance and leading to systematically poorer health outcomes among those without insurance (Patrick 2006). While it is expected that the Affordable Care Act will have a significant impact on the dental coverage of children in the United States, as pediatric dental care will be a required benefit of insurance plans in individual and small-group plans, it is expected to have less of an impact on extending dental insurance to adults (Vujicic 2013). The provisions of the ACA that extend dental

care to adults, mainly through expansion of Medicaid, are expected to only reduce the number of adults without dental coverage by 5% (Ibid). Determinants such as lack of dental insurance have shown relationships that are not specific to one country or culture. The social gradient in dental health and disease due to social determinants has been shown to hold across time and country (Kwan 2010).

Another study, conducted in England in 1998, also found that barriers to dental care were due at least in part of low SES, and that the move in the country towards greater privatization of dental services had increased inequality, as those without the financial means to pay for preventive services had less dental care and poorer health outcomes (Donaldson 2008). These similar results indicate that social determinants can greatly affect oral health in a variety of cultural situations.

Inequalities in the United States are found in populations of both children and adults. Children in poverty or living with disabilities experience significantly poorer oral health outcomes than their peers, and adults with low SES, of minority racial background, and without jobs are similarly affected. Efforts to reduce these disparities though the extension of insurance by expanding the Medicaid and Medicare systems has still been ineffective. While some hypothesize that the low reimbursement rates set by these programs leads to a lack of provider acceptance of these underserved patients, it must

also be acknowledged that despite these recent extensions in dental insurance, inequalities are still flourishing (Donaldson 2008).

Therefore, research has begun to explore other determinants of oral health, beyond low SES, lack of dental insurance and poor oral health outcomes. A study published in 2011 (using the 1988-1994 NHANES data) found that "compared with mothers who had no untreated caries, mothers who had high levels of untreated caries were more than three times as likely to have children who had an increasing extent of caries experience (that is, treated or untreated dental caries). We observed a similar relationship between mothers' tooth loss and the extent of caries experience and untreated caries among their children" (Dye 2011). This study finds that maternal oral health can be a determinant of early childhood oral health outcomes, and perhaps even more distally, raises questions about what environmental and community factors (such as a lack of qualified oral health practitioners serving an area, for instance) may be affecting both maternal and child oral health. In addition to maternal oral health, parental socioeconomic status, dental care behavior, and attitudes have been shown to be associated with the prevalence of caries in children (Wigen 2010; Mantonanaki 2013). The relationship of parental factors on child oral health has also been shown to include parents' age and education (Van den Branden 2012). Improving parental oral health, along with behaviors, beliefs and attitudes, may

help to improve early childhood oral health, and is an avenue worth pursuing.

Addressing disparities in childhood oral health is proving to be quite complicated. Despite awareness of the issue and advances in treatment and prevention, the rate of childhood caries only decreased 2% between 1986 and 1995 (Mouradian 2000) and the trend reversed between 1999 and 2004 (National Institutes of Health 2013). Caries prevalence is unevenly distributed; not only do minority children and those of lower socioeconomic status face a higher risk of caries, but any decay is also more likely to be untreated (Mouradian 2000). Between the years of 2009 to 2010, non-Hispanic white children between the ages of 3 and 5 were nearly half as likely to have untreated dental caries as non-Hispanic black and Hispanic children (Dye 2012). This trend largely holds for children up to age 15 (Ibid). The disproportionate distribution of caries among children is further illustrated by the finding that 20-25% of children experience 80% of all caries, another indication that behavioral change approaches to improving oral health may not be sufficient for equality (Mouradian 2000). For example, water fluoridation has a well-known positive impact on childhood oral health. But, even though this intervention is known to be effective, only 62% of American children drink fluoridated water. While the 38% of children without fluoride are already at increased risk of caries, this risk will be compounded in some children who are also subject to a variety of other negative

determinants (low SES leading to fewer dental visits, diets higher in processed foods and sugar, poorer family oral health and habits, etc). For the children who face several risk factors together, the overall risk of negative oral health outcomes may rise significantly and lead to increased costs and morbidity (Mouradian 2000). This synergistic effect of negative determinants is important to keep in mind, and should be the subject of future policy research.

In adults, these determinants are also important, but some other factors have also been identified. As discussed in Section 3, the direction of the relationship between cognitive function and oral health has not yet been determined; however there is a growing body of research studying the impact of cognitive function on oral health. A 2010 paper looking at the connection between "cognitive ability" and oral health outcomes from the 1988-1994 NHANES found a significant relationship between lower cognitive ability and poorer oral health, a relationship that even attenuated the effect of socioeconomic status on oral health (but did not replace it) (Sabbah 2010). Lower scores achieved on a simple reaction time test, symbol digit substitution test, and serial digit learning test all were correlated with worse oral health outcomes, and debate is ongoing about the direction of this relationships (Does lower cognitive ability lead to worse self-care and poorer oral health? Or does inflammation from periodontal disease lead to

reduced cognitive abilities?) (Sabbah 2009). Again, this area should be the focus of more research.

Finally, oral cancer also has significant social determinants; a 2011 paper found that, worldwide, the morbidity and mortality burden of oral cancer is quite high, and can be attributed in large part to modifiable lifestyle factors ("Tobacco, areca nut, alcohol, poor diet, viral infections, and pollution are all important etiological factors") that are also greatly influenced by broader determinants of health (like a lack of "control of the environment; safe water; adequate food; public and professional education about early signs and symptoms; early diagnosis and intervention; evidence-based treatments appropriate to available resources; and thoughtful rehabilitation and palliative care") (Johnson 2011). These risks are not equally distributed throughout the population, and neither is oral cancer incidence. Improving these statistics will, therefore, require more than individual behavior modification, and the authors urge a common-risk factor approach for the whole population (Johnson 2011).

While the shift in focus from behavioral factors of oral health to social determinants has been recent, the current literature is almost universally in agreement; the circumstances that an individual faces, not just the decisions and lifestyle choices of the individual, are highly relevant to oral health outcomes, and any efforts to improve oral

health must target these circumstances to affect real, sustained change.

## 2.5 Risk Factors for Tooth Loss

Tooth loss is the result of multiple factors, some health related, some lifestyle related, and some derived from demographic and socioeconomic influences (Cristiano et al. 2006; Moreira et al. 2010; Chatrchaiwiwatana 2007; Cristiano et al. 2005; Haugejordan et al. 2003; Arora et al. 2010; Jiang 2013; Klein et al. 2004; Copeland et al. 2004; Ng and Leung 2006; Wennström 2013) . While tooth loss in young people is significantly associated with a history of more than two teeth with dental caries (Cristiano et al. 2006), demographic and socioeconomic characteristics along with general health status, oral health status, and oral hygiene behavior contribute to tooth loss in the older adult population (Moreira et al. 2010).

The loss of teeth is also associated with behavior. Poor diet and use of tobacco have been found to result in a greater risk of tooth loss (Jiang 2013). Smokeless tobacco use has been shown to result in poor dental health and increase the likelihood of tooth loss (Agbor 2013).

Trends of engaging in behaviors that are risk factors for poor oral health may vary by country and culture. In Thailand, age, smoking, chewing betel nuts, dental caries and

periodontitis were the most significant factors contributing to lost teeth in a rural population (Chatrchaiwiwatana 2007).

A study of older adults in Brazil assessed the prevalence, extent, and risk indicators for tooth loss, revealing that the extent of tooth loss was similar in males and females and increased sharply with age; loss of more than four teeth was associated with low socioeconomic status and heavy smoking, and adults with a history of dental caries or filled teeth were more likely to lose teeth (Cristiano et al. 2005).

In Norway, the only significant predictor of the incidence of tooth loss after controlling for other socio-demographic variables was a lower educational level (Haugejordan et al. 2003). Except for the Norwegian study of 12-month incidence, authors of the above studies recommended education and promotion to discourage behaviors contributing to poor oral health and to encourage preventive dental hygiene behaviors.

Smoking, heavy alcohol consumption and education were identified as lifestyle correlates of tooth loss and these investigators, too, suggested that modifying these may reduce risk of tooth loss in older adults (Klein et al. 2004). Another study of risk factors for tooth loss cautions that there may be limits to how much we can generalize tooth loss findings across different study cohorts and that important differences may exist in risk

factors between specific populations (Copeland et al. 2004).

# Chapter 3. CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES/QUESTIONS

Informed by the determinants of health model that focuses on personal characteristics, behavioral characteristics, and health care practices (Shi and Singh 2012), and an up-to-date literature review, we propose the conceptual framework that provides guidance for the analyses (see the following page). Specifically, the outcomes of interest include quality of life indicators (as measured by the eight SF-36 quality of life domains) and loss of teeth among adults. These outcomes are hypothesized to be influenced by four classes of factors: individuals' personal factors such as demographic, socioeconomic, and lifestyle behavioral characteristics, individuals' oral hygiene behavior, individuals' use of dental services, and individuals' self-assessed dental health status.

The conceptual framework further informs the formulation of the research hypotheses and questions under each study aim as specified below.

**Study Aim 1**: Identify current dental hygiene practice and dental health status among Taiwanese population.

**Research Question 1:** What is the current dental hygiene practice among Taiwanese population?

**Research Question 2:** What is the current dental health status among Taiwanese population?

**Study Aim 2**: Study the association between dental hygiene practice, dental health status, and quality of life indicators.

**Research Hypothesis 1:** There is a significant and positive association between dental hygiene practice and quality of life after controlling for known determinants of quality of life.

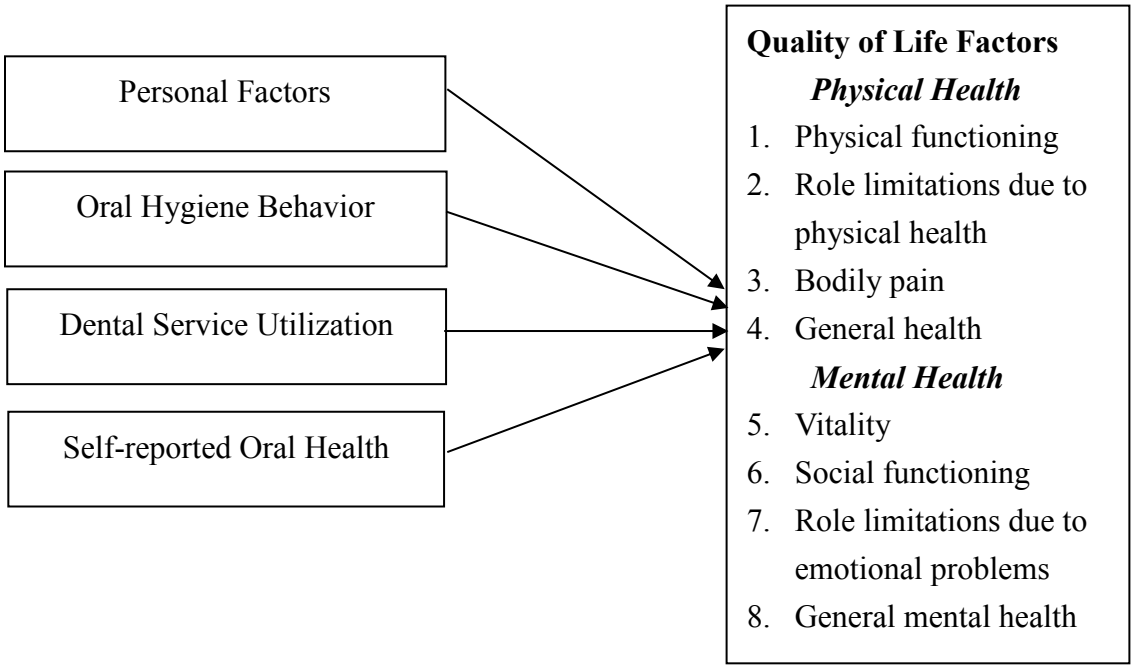
**Research Hypothesis 2:** There is a significant and positive association between dental health status and quality of life after controlling for known determinants of quality of life.

**Study Aim 3**: Assess factors associated with tooth loss among Taiwanese population.

**Research Hypothesis 3:** There is a significant and positive association between dental hygiene practice and tooth loss after controlling for known determinants of tooth loss**.**

**Research Hypothesis 4:** There is a significant and positive association between dental health status and tooth loss after controlling for known determinants of quality of life.

**Figure 3.1 Conceptual Framework for the Research**



# Chapter 4. METHODS

This study is uses a cross-sectional design and secondary database to analyze data from the National Health Interview Survey provided by the Bureau of Health Promotion, National Health Research Institutes and Food and Drug Administration of the Department of Health, Executive Yuan, Taiwan. The interpretation and conclusions contained herein do not represent those of the Bureau of Health Promotion or National Health Research Institutes and Food and Drug Administration, Department of Health, Executive Yuan.

## 4.1 Data Collection

Data of 18,099 subjects with ages ranging from 12-64 years were collected from the National Health Interview Survey (NHIS) conducted in Taiwan in 2005. Of these, 15,798 adult subjects with ages ranging from 18-64 years who had completed the Short Form Health Survey (SF-36) (Ware and Sherbourne 1993) were included in the data analysis.

The population of the 2005 Taiwan NHIS were the community dwellers with household registry from 23 cities and counties in Taiwan. The National Registry Database in December 31st, 2004 served as the population to be sampled.

The sampling procedure adopted a multi-stage stratified systematic sampling design by sampling city, township, neighborhood, and individual by probability proportional to size and interval sampling. In view of the difference of urbanization and geography, 53 strata were stratified and designated as sampling units. According to the National Registry Database in December 31st, 2004, the total population was 22,615,307. From 187 townships of 23 cities and counties, the total sample size selected was 30,680.

The NHIS was conducted in 2005 by the Population and Health Research Center,

Bureau of Health Promotion, Department of Health R.O.C. (Taiwan). It used a multi-stage stratified systematic sampling design that allowed data to represent the population nationally. The survey primarily approached the individual questionnaire survey by face-to-face interview. The interview questionnaire was divided as three categories based on the age groups, “under 12 years old”, “12 to 64 years old”, and “over 65 years old.”A parent or family member was responsible to answer the interview for the children under 12 years old. The questionnaires of “12 to 64 years old” and “over 65 years old” must be completed in person; unless the cases are unable to respond by themselves due to unconsciousness, serious illness, intellectual disability, deaf, or mute. In these cases, the proxy can respond on behalf of the cases. 357 well-trained interviewers spent about four months to complete the field interview of selected participants. The total number of completed interview was 24,726, and the response rate was 80.59%.

The questionnaire of 2005 NHIS was inherited from the investigation of 2001 NHIS. The questionnaire design of 2001 NHIS went through a serious of strict processes: determining the directions of questionnaire based on health indicators, collecting related information at home and abroad, expert meeting, draft questionnaire, expert review, finalizing questionnaire, and pre-test and revision. With some modifications according to the demand of health indicators and health issues in different age groups, 2005 NHIS also held expert meeting and pre-test to increase the reliability and validity of the questionnaire.

For the purpose of our analyses, a total of 24,726 Taiwanese adults aged 18-64 completed the survey (response rate 80.6%) and each provided signed informed consent.

All family members of selected households participated and were interviewed by well trained interviewers. All data were released to the public. Variables measured by this instrument included demographics (age, gender, education, marital status, income and body mass index (BMI)); disease history; lifestyle behavior (smoking, consuming alcohol, betel nut chewing); oral hygiene behavior (number of times brushing teeth daily, timing of brushing teeth, frequency using dental floss, mouthwash and dental scaling); self-reported oral health (number of lost teeth, dental prosthesis, oral health status, self-limitation of food due to oral health status); and dental care utilization.

The Short-form Health Survey (SF-36) is a multi-purpose, generic short-form health survey with 36 questions in eight domains corresponding to eight health concepts selected from the Medical Outcomes Study (MOS) (Ware and Sherbourne 1993). The eight quality-of-life domains defined in the SF-36 questionnaire are: 1. General health, 2. Social functioning, 3. Emotional well being, 4. Physical functioning, 5. Role limitations due to physical health, 6. Role limitations due to emotional problems, 7. Energy/fatigue, and 8. Pain. Each completed questionnaire yields functional health and well being scores, a psychometrically-based physical and mental health summary and an individual preference-based health utility index (Ware et al. 1993). Instrument validity and reliability are acceptable as determined in previously published psychometric evaluation (Ware and Sherbourne 1993; Ware et al. 1993). In the present study, a Chinese version of this instrument was used to evaluate health-related quality of life (Ware et al. 1995).

## 4.2 Measurement

The measures used in this study are informed by the conceptual framework that

identifies the domains of interest. Two categories of dependent variables are: quality of life-indicators and loss of teeth. Loss of teeth is defined as actual missing of teeth not including artificial implants. The quality-of-life indicators are obtained from the SF-36 questionnaire including eight specific domains: general health, social functioning, emotional well being, physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, and pain. Loss of teeth is from the National Health Interview Survey.

Although the SF-36 has been effectively applied in numerous health outcome studies of specific populations and in differentiating health benefits of various treatments, the National Health Interview Survey adapted it to evaluate general quality of life and it must be noted that the SF-36 is not specifically designed to measure oral health-related quality of life. Because of the reported connection between oral health and systemic health (Department of Health and Human Services 2000), and demonstrated applicability of the SF-36 toward the purpose of the present study, it appears able to address aspects of oral health-related quality of life. Kuo et al. agree that use of the SF-36 provided a good reference for comparing prosthetic needs with other health problems in Taiwan.

Independent variables include both personal characteristics and dental related measures. Personal characteristics include individuals' sociodemographic characteristics such as age, gender, BMI, income, education, and marital status; disease history such as whether having hypertension, diabetes mellitus, hyperlipidemia, stroke, asthma, kidney disease, and heart disease; and lifestyle behaviors such as current alcohol use, history of

smoking, and history of chewing betel nuts. Table 4.1 provides the operationalization of these measures.

Dental related measures include oral hygiene practice measures such as daily frequency of teeth brush, time of teeth brushing, frequency of using dental floss, frequency of using mouthwash, and having dental scaling every sixth month. Dental service use such as dental visit in the last year, self-reported oral health measures such as number of lost teeth, have dental prosthesis, self-evaluation of dental function, and self-limitation of food choices due to dental function. Table 4.2 provides the operationalization of these measures.

Table 4.1. Measures of Personal Characteristics

| | | N = 15501 |
|---|---|---|
| **Demographics** | Categories | |
| Age (year) | | |
| Gender | Male | |
| | Female | |
| BMI* (kg/m2) | | |
| Monthly income in prior year (NTD)* | <5000 | |
| | 5000~20000 | |
| | 20000~80000 | |
| | > 80000 | |
| Education level | Illiterate | |
| | Junior high school or below | |
| | Senior high school | |
| | College | |
| | Graduate school or above | |
| | Others | |
| Marital status | Married/cohabited | |
| | Single | |
| | Divorced/separated | |
| | Widowed | |
| | Other | |
| **Disease history** | | |
| Hypertension | | |
| Diabetes mellitus | | |
| Hyperlipidemia | | |
| Stroke | | |
| Asthma | | |
| Kidney disease | | |
| Heart disease | | |
| **Lifestyle behaviors** | | |
| Current alcohol use | | |
| History of smoking | | |
| History of chewing betel nuts | | |

*BMI, body mass index; NTD New Taiwan dollars

**Table 4.2. Measures of oral hygiene behaviors, oral health status, and dental service use**

| | |
|---|---|
| **Oral hygiene behaviors** | |
| Daily frequency of teeth brushing (number of times) | 0~1 |
| | 2 |
| | ≥3 |
| Time of teeth brushing | |
| After getting up | |
| After breakfast | |
| After lunch | |
| After dinner | |
| After every time eating | |
| Before sleep | |
| Frequency of using dental floss | Almost every day |
| | Occasionally |
| | No |
| Frequency of using mouthwash | Almost every day |
| | Occasionally |
| | No |
| Have dental scaling every six months | |
| **Self-reported oral health** | |
| Number of lost teeth | None |
| | 1~8 |
| | ≥9 |
| Have dental prosthesis | |
| Self-evaluation of dental function | Very bad |
| | Bad |
| | Fair |
| | Good |
| | Very good |
| Self-limitation of food choices due to dental function | Never |
| | Occasionally |
| | Sometimes |
| | Frequently |
| | Always |
| **Had dental visit in the last year** | Yes/No? |

## 4.3 Statistical Analysis

Both descriptive and multivariate analyses were performed to study the research questions and hypotheses. For continuous data, means and standard deviations are presented. For categorical variables, count and percentage are presented. Simple and multiple linear regression models are performed to investigate the impact of demographics, lifestyle behaviors, dental preventive care, and self-reported oral health on the eight domains of quality of life as obtained from the SF-36. Linear regression models are summarized by coefficient of variation (β) with 95% confidence interval (CI) (see Table 4.3 for the template of these analyses). Univariate and multivariate logistic regression models are performed to investigate the impact of demographics, lifestyle, dental preventive care, and oral health status on the risk for lost teeth. Logistic regression models are summarized by odds ratio (OR) and with 95% confidence interval (CI) (see Table 4.4 for the template of these analyses). For descriptive statistics, weighted sample is used so that results are generalizable to the nation. For regression analyses, raw sample is used so that subjects are not double-counted in the analyses.

Multi-colinearity is evaluated by variance inflationary factor (VIF). Each VIF of variables determined to be significant by univariate analysis is evaluated. Variables with VIF over five are then considered to have multi-collinearity with other covariates and are excluded from multivariate analyses. Other variables determined to be significant by univariate analysis are stepwise entered into multivariate analysis. Statistical tests are two-sided and significance level is set at 0.05. Statistical analyses are performed by SPSS software version15.0 (SPSS Inc., Chicago, IL).

## 4.4 Human Subjects

Since secondary dataset is used and no individual identifier is kept in the dataset, no discernable human subject concerns are anticipated. Moreover, the large sample size makes it impossible to trace individual identity based on the demographic information.

## 4.5 Timeline of Activities

Table 4.5 displays the timeline of the major activities connected with the thesis research.

**Table 4.3. Template of multivariate general linear model for quality of life indicators**

| | | General health | | Social functioning | | Emotional well being | | Physical functioning | |
|---|---|---|---|---|---|---|---|---|---|
| | | β (95% CI) | P-value | β (95% CI) | P-value | β (95% CI) | P-value | β (95% CI) | P-value |
| **Demographics** | | | | | | | | | |
| Age (year) | | | | | | | | | |
| Gender (male vs. female) | | | | | | | | | |
| Marriage status | Married/cohabited | | | | | | | | |
| | Single | | | | | | | | |
| | Divorced/separated | | | | | | | | |
| | Widowed | | | | | | | | |
| | Other | | | | | | | | |
| Monthly income in the last year | <5000 | | | | | | | | |
| | 5001~20000 | | | | | | | | |
| | 20001~80000 | | | | | | | | |
| | > 80000 | | | | | | | | |
| BMI* (kg/m2) | | | | | | | | | |
| **Disease history** | | | | | | | | | |
| Hypertension | | | | | | | | | |
| Diabetes mellitus | | | | | | | | | |
| Hyperlipidemia | | | | | | | | | |
| Stroke | | | | | | | | | |
| Asthma | | | | | | | | | |
| Kidney disease | | | | | | | | | |
| Heart disease | | | | | | | | | |
| **Lifestyle behaviors** | | | | | | | | | |
| Current use of alcohol | | | | | | | | | |
| History of chewing betel nuts | | | | | | | | | |
| **Oral hygiene behaviors** | | | | | | | | | |

| | | |
|---|---|---|
| Daily frequency of teeth brushing | 0~1 | |
| | 2 | |
| | ≥3 | |
| Brushing teeth after getting up | | |
| Brushing teeth before sleep | | |
| Frequency of using dental floss | No | |
| | Occasionally | |
| | Almost every day | |
| Have dental scaling every six months | | |
| **Self-reported oral health** | | |
| Number of lost teeth | None | |
| | 1~8 | |
| | ≥9 | |
| Have dental prosthesis | | |
| Self limitation of food choices due to dental health | Never | |
| | Occasionally | |
| | Sometimes | |
| | Frequently | |
| | Always | |
| **Had dental visit in the last year** | | |

**Table 4.3. Template of multivariate general linear models for quality-of-life indicators (continued)**

| | | Role limitations due to physical health | | Role limitations due to emotional problems | | Energy/ fatigue | | Pain | |
|---|---|---|---|---|---|---|---|---|---|
| | | β (95% CI) | P-value | β (95% CI) | P-value | β (95% CI) | P-value | β (95% CI) | P-value |
| **Demographics** | | | | | | | | | |
| Age (year) | | | | | | | | | |
| Gender | | | | | | | | | |
| Marriage status | Married/cohabited | | | | | | | | |
| | Single | | | | | | | | |
| | Divorced/separated | | | | | | | | |
| | Widowed | | | | | | | | |
| | Other | | | | | | | | |
| Monthly income in the last year | <5000 | | | | | | | | |
| | 5000~20000 | | | | | | | | |
| | 20000~80000 | | | | | | | | |
| | > 80000 | | | | | | | | |
| BMI (kg/m2) | | | | | | | | | |
| **Disease history** | | | | | | | | | |
| Hypertension | | | | | | | | | |
| Diabetes mellitus | | | | | | | | | |
| Hyperlipidemia | | | | | | | | | |
| Stroke | | | | | | | | | |
| Asthma | | | | | | | | | |
| Kidney disease | | | | | | | | | |
| Heart disease | | | | | | | | | |
| **Lifestyle behaviors** | | | | | | | | | |
| Current drinking | | | | | | | | | |

| | |
|---|---|
| Ever smoking | |
| **Oral hygiene behavior** | |
| Daily frequency of tooth brushing | 0~1 |
| | 2 |
| | ≥3 |
| Have tooth brushing after getting up | |
| Have tooth brushing before sleep | |
| Frequency of using dental floss | No |
| | Occasionally |
| | Almost every day |
| Frequency of using mouthwash | No |
| | Occasionally |
| | Almost every day |
| Have dental scaling per six month | |
| **Self-reported oral health** | |
| Number of loss tooth | None |
| | 1~8 |
| | ≥9 |
| Self limitation for food due to dental health | Never |
| | Occasionally |
| | Sometimes |
| | Frequently |
| | Always |
| **Had dental visit in the last year** | |

**Table 4.4. Template of univariate and multivariate logistic regression models for risk of lost teeth**

| | | Univariate | | Multivariate | |
|---|---|---|---|---|---|
| | | **OR (95% CI)** | **P-value** | **OR (95% CI)** | **P-value** |
| **Demographics** | | | | | |
| Age (year) | | | | | |
| Gender | | | | | |
| Education[a] | Illiterate | | | | |
| | Junior high school or below | | | | |
| | Senior high school | | | | |
| | College | | | | |
| | Graduate school or above | | | | |
| | Others | | | | |
| Marriage status | Married/cohabite | | | | |
| | Single | | | | |
| | Divorced/separated | | | | |
| | Widowed | | | | |
| | Other | | | | |
| Monthly income in the last year | <5000 | | | | |
| | 5000~20000 | | | | |
| | 20000~80000 | | | | |
| | > 80000 | | | | |
| BMI (kg/m2) | | | | | |
| **Disease history** | | | | | |
| Hypertension | | | | | |
| Diabetes mellitus | | | | | |
| Hyperlipidemia | | | | | |
| Stroke | | | | | |
| Asthma | | | | | |
| Kidney disease | | | | | |
| Heart disease | | | | | |
| **Lifestyle behaviors** | | | | | |
| Current drinking | | | | | |
| Ever smoking | | | | | |
| Ever chewing betelnut | | | | | |
| **Oral hygine behaviors** | | | | | |
| Daily frequency of tooth brushing[a] | 0~1 | | | | |
| | 2 | | | | |
| | ≥3 | | | | |
| Had tooth brushing after getting up | | | | | |
| Had tooth brushing after breakfast | | | | | |
| Had tooth brushing after lunch | | | | | |
| Had tooth brushing after dinner | | | | | |

| | |
|---|---|
| Every time after eating | |
| Before sleep | |
| Frequency of using dental floss | No |
| | Occasionally |
| | Almost every |
| Frequency of using mouthwash | No |
| | Occasionally |
| | Almost every |
| Have dental scaling per six month | |
| **Self-reported oral health** | |
| With dental prosthesis | |
| Self evaluation of tooth function[a] | Very bad |
| | Bad |
| | Fair |
| | Good |
| | Very good |
| Self limitation for food due to dental health | Never |
| | Occasionally |
| | Sometimes |
| | Frequently |
| | Always |
| **Had dental visit in the last year** | |

**Table 4.5. Schedule of Thesis Research Activities**

| | **Fall 2012** | **Winter 2012** | **Spring 2013** | **Summer 2013** | **Fall 2013** | **Winter 2013** | **Spring 2014** | **Summer 2014** |
|---|---|---|---|---|---|---|---|---|
| Literature review | | | | | | | | |
| Study aims | | | | | | | | |
| Research questions | | | | | | | | |
| Conceptual framework hypotheses | | | | | | | | |
| Research design | | | | | | | | |
| Preliminary analysis | | | | | | | | |
| Proposal writing & presentation | | | | | | | | |
| Data preparation | | | | | | | | |
| Data coding merging | | | | | | | | |
| Statistical analysis | | | | | | | | |
| Refined analyses | | | | | | | | |
| Dissertation manuscript | | | | | | | | |
| Defense of dissertation | | | | | | | | |
| Revision of dissertation | | | | | | | | |

# Chapter 5. STUDY RESULTS

## 5.1 Descriptive Analysis of Participants' Personal Factors

The unweighted sample size is 15,798. After adjusting for national sample size, the weighted sample size is 16,634. We will use weighted sample size for the following analyses. Table 5.1 presents the basic information about the Taiwanese adults who were enrolled in this study. Based on the composition of age groups, the largest group was 18-29 (29.6%), followed by 30-39 (24.3%), 40-49 (24.4%), 50-59 (16.4%), and 60-64 (5.3%), Both genders had nearly equal distribution in the sample. Most of the study subjects had only senior high school education, followed by bachelor degree (32.5%) and junior high school (28.2%). Among them, 60% were married; only 4% were divorced or separated. Most had incomes ranging from 20,000 to 80,000 NT dollars (54.2%).

Hyperlipidemia was the most common self-reported disease with 11.6% of study subjects reporting having a history of it, followed by hypertension (9.0%). The proportions of reporting diabetes, kidney disease, heart disease, asthma, and stroke were 3.5%, 3.5%, 3.3%, 1.8%, and 0.5%, respectively.

The average BMI of the Taiwanese adults was within the normal range 23.33 $kg/m^2$ (S.E.=0.05). The proportions of alcohol or cigarette use were quite high. More than one third of the study subjects were current alcohol drinkers (38.6%) and 27.4% were currently smoking. Betel nut chewing was another additive harmful behavior with 9.2% currently chewing and 4.5% former users.

**Table 5.1 The descriptive distribution of Taiwanese adults' personal factors**

| | Weighted count[§] | | Unweighted count | |
|---|---|---|---|---|
| | n | % | n | % |
| **Demographics** | | | | |
| Age Group | | | | |
| 18~29 | 4899 | 29.6% | 4607 | 29.2% |
| 30~39 | 4016 | 24.3% | 3616 | 22.9% |
| 40~49 | 4029 | 24.4% | 3828 | 24.2% |
| 50~59 | 2714 | 16.4% | 2755 | 17.4% |
| 60~64 | 876 | 5.3% | 992 | 6.3% |
| Gender | | | | |
| Female | 8189 | 49.5% | 7722 | 48.9% |
| Male | 8345 | 50.5% | 8076 | 51.1% |
| Education | | | | |
| Illiterate | 387 | 2.3% | 447 | 2.8% |
| Junior high school or below | 4668 | 28.2% | 4807 | 30.4% |
| Senior high school | 5479 | 33.2% | 5191 | 32.9% |
| Bachelor degree | 5374 | 32.5% | 4801 | 30.4% |
| Graduate or higher | 616 | 3.7% | 542 | 3.4% |
| Marital Status | | | | |
| Single | 5407 | 32.7% | 5061 | 32.0% |
| Married | 9998 | 60.5% | 9602 | 60.8% |
| Divorced or separated | 663 | 4.0% | 644 | 4.1% |
| Widowed | 427 | 2.6% | 453 | 2.9% |
| Other | 39 | .2% | 37 | 0.2% |
| Monthly Income | | | | |
| <5,000 | 3639 | 22.2% | 3645 | 23.2% |
| 5,000-20,000 | 3284 | 20.0% | 3344 | 21.3% |
| 20,000-80,000 | 8895 | 54.2% | 8166 | 52.1% |
| >80,000 | 606 | 3.7% | 526 | 3.4% |
| Currently working | | | | |

**Table 5.1 The descriptive distribution of Taiwanese adults' personal factors**

| | Weighted count§ | | Unweighted count | |
|---|---|---|---|---|
| | n | % | n | % |
| No | 4797 | 29.0% | 4766 | 30.2% |
| Yes | 11730 | 71.0% | 11025 | 69.8% |
| **Disease History** | | | | |
| Hypertension | 1481 | 9.0% | 1511 | 9.6% |
| Diabetes | 586 | 3.5% | 605 | 3.8% |
| Hyperlipidemia | 1916 | 11.6% | 1848 | 11.7% |
| Stroke | 83 | 0.5% | 89 | 0.6% |
| Asthma | 299 | 1.8% | 301 | 1.9% |
| Kidney Disease | 579 | 3.5% | 554 | 3.5% |
| Heart Disease | 546 | 3.3% | 564 | 3.6% |
| **Health Behaviors** | | | | |
| BMI | Mean | S.E. | | |
| | 23.33 | 0.053 | | |
| Alcohol Drinking | | | | |
| No | 10153 | 61.4% | 9727 | 61.6% |
| Yes | 6377 | 38.6% | 6067 | 38.4% |
| Cigarette Smoking | | | | |
| Never smoked | 11365 | 68.7% | 10781 | 68.3% |
| Quitted smoking | 631 | 3.8% | 592 | 3.7% |
| Currently Smoking | 4535 | 27.4% | 4422 | 28.0% |
| Betel Nut Chewing | | | | |
| Never chewed | 14268 | 86.3% | 13491 | 85.4% |
| Quitted chewing | 737 | 4.5% | 704 | 4.5% |
| Currently Chewing | 1527 | 9.2% | 1599 | 10.1% |

§ The unweighted sample size is 15,798. The weighted sample size is 16,634.

## 5.2 Descriptive Analysis of Participants' Oral Hygiene Behaviors and Self-Reported Oral Health

Table 5.2 presents the descriptive information about study subjects' oral hygiene behaviors and oral health. The distribution of daily frequency of brushing teeth shows that most people had good behavior of brushing teeth. Only 22.9% brushed teeth equal or less than one time. Brushing teeth after getting up had the greatest percentage (94.1%) and the second highest was brushing before sleep (77.3%). Half of the adults had no habit of using dental floss to clean their teeth (50.5%). About 85% of the study subjects did not use mouthwash. Most of the Taiwanese adults did not have dental scaling every six months (83.7%). However, 40.8% have ever visited dentist in the last year.

The self-reported oral health shows that half of the subjects had dental prosthesis (50.7%). In addition, 60.8% had not lost any tooth, 35.8% lost 1 to 8 teeth, and 3.4% lost more than 9 teeth. The proportions of the self-evaluation of dental function, rated on a five-point scale as very bad, bad, fair, good, and very good, were 2.9%, 14.9%, 39.3%, 30.9%, and 12.0%, respectively. Because of poor dental function, 12.8% occasionally limited their food choices, 13.3% limited sometimes, 3.2% limited frequently, and 1.6% always did so.

**Table 5.2 The descriptive distribution of Taiwanese adults' oral hygiene behaviors**

| | Weighted count[§] | | Unweighted count | |
|---|---|---|---|---|
| | n | % | n | % |
| **Oral Hygiene Behaviors** | | | | |
| Daily frequency of brushing teeth | | | | |
| 0-1 time | 3779 | 22.9% | 3628 | 23.0% |
| 2 times | 11034 | 66.9% | 10503 | 66.6% |
| ≧3 times | 1687 | 10.2% | 1631 | 10.3% |
| Using dental floss | | | | |
| No | 8328 | 50.5% | 8156 | 51.8% |
| Occasionally | 4221 | 25.6% | 3968 | 25.2% |
| Almost every day | 3940 | 23.9% | 3628 | 23.0% |
| Using mouthwash | | | | |
| No | 14082 | 85.2% | 13551 | 85.9% |
| Occasionally | 1930 | 11.7% | 1755 | 11.1% |
| Almost every day | 508 | 3.1% | 476 | 3.0% |
| Having dental scaling every 6 months | | | | |
| No | 13816 | 83.7% | 13329 | 84.5% |
| Yes | 2689 | 16.3% | 2441 | 15.5% |
| Dental visit in the last year | | | | |
| No | 9782 | 59.2% | 9518 | 60.3% |
| Yes | 6750 | 40.8% | 6277 | 39.7% |
| Time of brushing teeth | | | | |
| After getting up | 15466 | 94.1% | 14777 | 94.2% |
| After breakfast | 631 | 3.8% | 601 | 3.8% |
| After lunch | 1469 | 8.9% | 1406 | 9.0% |
| After dinner | 881 | 5.4% | 819 | 5.2% |
| After every time eating | 235 | 1.4% | 228 | 1.5% |
| Before sleep | 12706 | 77.3% | 12133 | 77.4% |

**Table 5.2 The descriptive distribution of Taiwanese adults' oral hygiene behaviors**

| | Weighted count§ | | Unweighted count | |
|---|---|---|---|---|
| | n | % | n | % |
| **Self-Reported Oral Health** | | | | |
| Dental prosthesis | | | | |
| No | 8136 | 49.3% | 7753 | 49.1% |
| Yes | 8384 | 50.7% | 8030 | 50.9% |
| Teeth lost | | | | |
| None | 10002 | 60.8% | 9275 | 59.0% |
| 1-8 | 5897 | 35.8% | 5797 | 36.9% |
| >=9 | 563 | 3.4% | 641 | 4.1% |
| Self-evaluation of dental function | | | | |
| Very bad | 477 | 2.9% | 465 | 3.0% |
| Bad | 2446 | 14.9% | 2390 | 15.3% |
| Fair | 6446 | 39.3% | 6025 | 38.5% |
| Good | 5070 | 30.9% | 4879 | 31.1% |
| Very good | 1962 | 12.0% | 1909 | 12.2% |
| Self-limitation of food choices | | | | |
| Never | 11548 | 69.8% | 10887 | 68.9% |
| Occasionally | 2069 | 12.5% | 2017 | 12.8% |
| Sometimes | 2158 | 13.1% | 2115 | 13.4% |
| Frequently | 496 | 3.0% | 505 | 3.2% |
| Always | 262 | 1.6% | 273 | 1.7% |

§ The unweighted sample size is 15,798. The weighted sample size is 16,634.

## 5.3 Bivariate Analysis between Participants' Quality of Life and Personal Factors

The results of the bivariate analysis between study subjects' personal factors and quality of life are shown in Table 5.3 and Table 5.4. We found that quality of life, measured by SF-36, was significantly different across most of the demographic factors and disease histories. In general, those who were older, female, less educated, not working currently, or had less income reported lower scores on the eight sub-domains of SF-36. Not surprisingly, the adults with the disease history, hypertension, diabetes, hyperlipidemia, stroke, asthma, kidney disease, or heart disease reported lower scores in both physical health and medical health. Body mass index was negatively correlated with physical functioning, role limitations due to physical health, bodily pain, and general health; but positively correlated with vitality, social functioning, role limitations due to emotional problems, and general mental health. Current alcohol drinking was associated with physical functioning ($t=10.18$, $p<0.001$), role limitations due to physical health ($t=4.75$, $p<0.001$), bodily pain ($t=2.19$, $p<0.05$), and role limitations due to emotional problems ($t=2.81$, $p<0.001$). Smoking status was significantly correlated with the sub-domains of mental health except for social functioning. Betel nut chewing was associated with role limitations due to physical health ($F=11.00$, $p<0.001$), general health ($F=12.10$, $p<0.001$), vitality ($F=4.12$, $p<0.05$), and role limitations ($F=3.58$, $p<0.05$).

**Table 5.3 Bivariate analysis between physical health and personal factors**

| | Physical Health | | | |
|---|---|---|---|---|
| | PF | RP | BP | GH |
| **Demographics** | | | | |
| Age Group | F=156.9*** | F=79.47*** | F=8.98*** | F=27.49*** |
| Gender | t=10.96*** | t=6.11*** | t=12.90*** | t=8.19*** |
| Education | F=95.17*** | F=26.07*** | F=31.49*** | F=35.61*** |
| Marital Status | F=74.76*** | F=25.37*** | F=9.26*** | F=8.60*** |
| Monthly Income | F=86.32*** | F=75.51*** | F=14.00*** | F=18.43*** |
| Currently working | t=17.35*** | t=17.68*** | t=8.30*** | t=7.24*** |
| **Disease History** | | | | |
| Hypertension | t=-15.39*** | t=-10.84*** | t=-8.78*** | t=-15.14*** |
| Diabetes | t=-8.44*** | t=-5.56*** | t=-3.97*** | t=-10.33*** |
| Hyperlipidemia | t=-7.35*** | t=-6.70*** | t=-9.41*** | t=-11.43*** |
| Stroke | t=-7.66*** | t=-8.73*** | t=-3.29** | t=-6.16*** |
| Asthma | t=-7.45*** | t=-7.56*** | t=-4.94*** | t=-7.52*** |
| Kidney Disease | t=-11.34*** | t=-10.07*** | t=-9.55*** | t=-15.80*** |
| Heart Disease | t=-18.96*** | t=-11.12*** | t=-11.15*** | t=-19.37*** |
| **Health Behaviors** | | | | |
| BMI | r= -.096*** | r= -.034*** | r= -.022** | r= -.039*** |
| Alcohol Drinking | t=10.18*** | t=4.75*** | t=2.19* | t=1.57 |
| Cigarette Smoking | F=18.91*** | F=8.16** | F=6.52** | F=4.37* |
| Betel Nut Chewing | F=3.41 | F=11.00*** | F=1.81 | F=12.10*** |

Note:

PF=physical functioning; RP=role limitations due to physical health; BP=bodily pain; GH=general health

* P<.05, ** P<.01, *** P<.001

**Table 5.4 Bivariate analysis between mental health and personal factors**

| | Mental Health | | | |
|---|---|---|---|---|
| | VT | SF | RE | MH |
| **Demographics** | | | | |
| Age Group | F=10.59*** | F=8.14*** | F=11.34*** | F=23.56*** |
| Gender | t=15.67*** | t=4.80*** | t=1.70 | t=12.99*** |
| Education | F=8.42*** | F=18.74*** | F=4.45** | F=10.53*** |
| Marital Status | F=14.58*** | F=19.58*** | F=21.31*** | F=50.45*** |
| Monthly Income | F=9.80*** | F=24.46*** | F=21.83*** | F=22.67*** |
| Currently working | t=3.38** | t=10.41*** | t=7.83*** | t=6.17*** |
| **Disease History** | | | | |
| Hypertension | t=-6.24*** | t=-5.19*** | t=-2.90** | t=-2.96** |
| Diabetes | t=-2.74* | t=-3.01** | t=-1.36 | t=-1.06 |
| Hyperlipidemia | t=-4.19*** | t=-3.62** | t=-3.80** | t=-2.07* |
| Stroke | t=-4.39*** | t=-4.96*** | t=-4.32*** | t=-3.82** |
| Asthma | t=-4.64*** | t=-5.92*** | t=-3.45** | t=-6.78** |
| Kidney Disease | t=-5.14*** | t=-4.01** | t=-4.19*** | t=-3.62** |
| Heart Disease | t=-8.39*** | t=-5.95*** | t=-5.82*** | t=-8.56*** |
| **Health Behaviors** | | | | |
| BMI | r= .058*** | r= .044*** | r= .032*** | r= .083*** |
| Alcohol Drinking | t=1.81 | t=1.58 | t=-2.81* | t=0.88 |
| Cigarette Smoking | F=14.10*** | F=0.49 | F=4.32* | F=32.03*** |
| Betel Nut Chewing | F=4.12* | F=1.16 | F=3.58* | F=3.38 |

Note:

VT=vitality; SF=social functioning; RE=role limitations due to emotional problems; MH=general mental health

* P<.05, ** P<.01, *** P<.001

## 5.4 Bivariate Analysis of Participants' Quality of Life across Oral Hygiene Behaviors and Self-Reported Oral Health

Table 5.5 presents the results of bivariate analysis of physical health across oral hygiene behaviors and self-reported oral health. Daily frequency of brushing teeth was found to be correlated with the eight sub-domains of SF-36 and brushing more than twice a day had higher average scores. Using dental floss was significantly associated with physical functioning ($F=32.84$, $p<0.001$), role limitations due to physical health ($F=8.46$, $p<0.01$), general health ($F=34.72$, $p<0.001$), vitality ($F=13.28$, $p<0.001$), and general mental health ($F=3.58$, $p<0.05$). Higher scores were found in the group who used floss frequently. On the contrary, frequent use of mouthwash was significantly related to lower scores of role limitations due to physical health ($F=4.07$, $p<0.05$), social functioning ($F=5.28$, $p<0.05$), and general mental health ($F=3.94$, $p<0.05$). These findings could be interpreted as follows. Those with greater physical functioning, were more likely to be able to floss regularly, while those who have lower levels of physical functioning might resort to using mouthwash (easier) than flossing. Having dental scaling every 6 months had no correlation with mental health. Those who visited dentists in the last year turned out to have lower scores in bodily pain, general health, vitality, social functioning, role limitations due to emotional problems, and general mental health. These findings could be interpreted as follows. People who are in less pain, better health, etc. are more likely to be able to see the dentist. Self-reported oral health had strong correlation with both physical health and mental health.

**Table 5.5 The binary analysis between physical health, oral hygiene behaviors, and self-reported oral health**

| | Physical Health | | | |
|---|---|---|---|---|
| | PF | RP | BP | GH |
| **Oral Hygiene Behaviors** | | | | |
| Daily frequency of brushing teeth | F=19.53*** | F=11.17*** | F=10.02*** | F=55.49*** |
| Using dental floss | F=32.84*** | F=8.46** | F=0.19 | F=34.72*** |
| Using mouthwash | F=0.32 | F=4.07* | F=2.05 | F=0.49 |
| Having dental scaling every 6 months | t=4.89*** | t=0.55 | t=-0.04 | t=4.91*** |
| Dental visit in the last year | t=0.64 | t=-1.49 | t=-5.77*** | t=-4.01** |
| **Self-Reported Oral Health** | | | | |
| Dental prosthesis | t=-8.43*** | t=-5.61*** | t=-6.86*** | t=-5.24*** |
| Teeth lost | F=57.84*** | F=55.33*** | F=62.97*** | F=45.47*** |
| Self-evaluation of dental function | F=26.31*** | F=33.76*** | F=89.80*** | F=106.7*** |
| Self-limitation of food choices | F=70.86*** | F=46.82*** | F=101.0*** | F=179.5*** |

Note:

PF=physical functioning; RP=role limitations due to physical health; BP=bodily pain; GH=general health

* P<.05, ** P<.01, *** P<.001

**Table 5.6 The binary analysis between mental health, oral hygiene behaviors, and self-reported oral health**

| | Mental Health | | | |
|---|---|---|---|---|
| | VT | SF | RE | MH |
| **Oral Hygiene Behaviors** | | | | |
| Daily frequency of brushing teeth | F=19.49*** | F=8.26** | F=5.20* | F=12.32*** |
| Using dental floss | F=13.28*** | F=0.98 | F=1.43 | F=3.58* |
| Using mouthwash | F=0.70 | F=5.28* | F=0.71 | F=3.94* |
| Having dental scaling every 6 months | t=1.35 | t=0.54 | t=-0.30 | t=1.18 |
| Dental visit in the last year | t=-5.62*** | t=-3.84** | t=-3.79** | t=-4.96*** |
| **Self-Reported Oral Health** | | | | |
| Dental prosthesis | t=-2.30* | t=-0.38 | t=-0.15 | t=-0.48 |
| Teeth lost | F=15.83*** | F=17.57*** | F=7.59** | F=4.66* |
| Self-evaluation of dental function | F=30.72*** | F=33.63*** | F=54.88*** | F=19.30*** |
| Self-limitation of food choices | F=49.14*** | F=35.49*** | F=53.13*** | F=54.95*** |

Note:

VT=vitality; SF=social functioning; RE=role limitations due to emotional problems; MH=general mental health

* P<.05, ** P<.01, *** P<.001

## 5.5 Regression Models of Quality of Life

Regression models were built for each sub-domains of SF-36 and the results are present in Table 5.7 and Table 5.8. Older age groups had significantly poorer physical functioning and more role limitations due to physical health compared to younger groups;

however older age was not related to poor bodily pain and general health; age group "60~64" had two points higher average score than age group "18~29" in the two aspects. Older age was also significantly associated with better mental health in all of the four sub-domains. Male study subjects appeared to have significantly higher scores on both physical and mental health. Higher monthly income was found associated with better quality of life.

After controlling for other factors, disease history was associated with lower scores of SF-36. Those with a history of stroke had, on average, 22.14 points ($P<0.001$) lower and 27.16 points ($P<0.001$) lower scores of physical functioning and role limitations due to physical health, respectively. Heart disease history was also related to greater role limitations due to physical health ( $\beta$ =-16.28, $p<0.001$) and general health ( $\beta$ =-11.85, $p<0.001$). As for mental health, histories of stroke or heart disease were associated with lower scores.

One unit increase in body mass index was associated with 0.13 ($p<0.001$) lower score of physical functioning, but 0.12 ($p<0.01$) higher score in general health. Nevertheless, the increase in BMI had positive association with vitality ( $\beta$ =0.27), social functioning ( $\beta$ =0.20), role limitations due to emotional problems ( $\beta$ =0.25), and general mental health ( $\beta$ =0.30). These seemingly unusual results could be due to the nature of self-report as people tend to underestimate their weight in self-report. The current alcohol drinkers were found to have better physical functioning ( $\beta$ =0.74, $p<0.001$) compared to non-drinkers, but more role limitations due to emotional problems ( $\beta$ =-2.14, $p<0.001$) and poorer general mental health ( $\beta$ =-0.88, $p<0.01$). Currently smoking was negatively

associated with general health ( $\beta$ =-1.19, p<0.05), social functioning ( $\beta$ =-0.91, p<0.01), and role limitations due to emotional problems ( $\beta$ =-1.42, p<0.01). Those who quit smoking reported better general mental health compared to non-smokers ( $\beta$ =1.35, p<0.001).

Oral hygiene behaviors include daily frequency of brushing teeth, using dental floss, using mouthwash, having dental scaling every 6 months, and dental visit in the last year. After controlling for the demographic factors, we found that daily brushing teeth more than twice was significantly associated with improvement in both physical and mental health. Brushing teeth more than three times was related to even higher scores. Using dental floss almost every day was significantly associated with 1.53 (p<0.001), 2.08 (p<0.001), and 1.05 (p<0.01) increases in average scores of general health, vitality, and general mental health, respectively. These results suggest good dental practice is associated with good health in general. Using mouthwash was not significantly related to better quality of life. Having dental scaling every six months was associated with 1.85 (p<0.001) points lower score of role limitations due to physical health, but 1.18 (p<0.01) points higher score of general health. Dental visit in the last year was negatively associated with bodily pain ( $\beta$ =-1.05, p<0.01), general health ( $\beta$ =-1.17, p<0.001), vitality ( $\beta$ =-1.31, p<0.001), social functioning ( $\beta$ =-0.58, p<0.05), role limitations due to emotional problems ( $\beta$ =-1.40, p<0.01), and general mental health ( $\beta$ =-1.05, p<0.001).

Self-reported oral health included three variables: teeth lost, self-evaluation of dental function, and self-limitation of food choices (i.e., restriction of certain food due to poor dental conditions). We found that those who lost one to eight teeth had slightly better

general health ( $\beta$ =0.85, p<0.01), vitality ( $\beta$ =0.94, p<0.01), and general mental health ( $\beta$ =1.12, p<0.001) than those who did not lose any teeth. It must be cautioned that although these results were statistically significant, they were not practically significant as the magnitude of significance was quite limited. The participants who reported better dental function also reported better quality of life. Self-limitation of food choices negatively affected both physical and mental health. The more limitations in the food choices, the worse the quality of life they reported.

**Table 5.7 The regression analyses for the sub-domains of physical health**

| | Physical Health | | | |
|---|---|---|---|---|
| | PF | RP | BP | GH |
| **Demographics** | | | | |
| Age Group | | | | |
| 18~29 (Ref.) | | | | |
| 30~39 | -0.41 | -1.05* | -0.46 | 0.45 |
| 40~49 | -1.50*** | -1.62*** | 0.34 | -0.01 |
| 50~59 | -2.42*** | -1.75** | 1.39** | 0.24 |
| 60~64 | -4.73*** | -3.52** | 2.71** | 2.30** |
| Gender (Ref.=Female) | 1.79*** | 1.55*** | 4.08*** | 2.99*** |
| Education | | | | |
| Illiterate (Ref.) | | | | |
| Junior high school or below | 4.19*** | 2.79 | 4.26*** | 5.04*** |
| Senior high school | 4.75*** | 3.61 | 5.11*** | 6.89*** |
| Bachelor degree | 4.59*** | 3.92 | 5.17*** | 5.93*** |
| Graduate or higher | 4.70*** | 2.51 | 4.24** | 4.57*** |
| Monthly Income | | | | |
| <5,000 (Ref.) | | | | |
| 5,000-20,000 | 1.71*** | 4.04*** | -0.07 | 0.91* |
| 20,000-80,000 | 2.53*** | 7.30*** | 1.36** | 2.15*** |

**Table 5.7 The regression analyses for the sub-domains of physical health**

| | Physical Health | | | |
|---|---|---|---|---|
| | PF | RP | BP | GH |
| >80,000 | 2.60*** | 8.71*** | 3.26*** | 4.30*** |
| **Disease History** | | | | |
| Hypertension | -1.10*** | -3.62*** | -2.40*** | -5.58*** |
| Diabetes | -2.82*** | -4.04* | -0.76 | -7.48*** |
| Hyperlipidemia | -1.01** | -2.16** | -4.16*** | -4.41*** |
| Stroke | -22.14*** | -27.16*** | -1.12 | -3.72 |
| Asthma | -5.62*** | -9.55*** | -5.18*** | -9.42*** |
| Kidney Disease | -3.96*** | -5.94*** | -4.05*** | -6.33*** |
| Heart Disease | -7.84*** | -16.28*** | -9.53*** | -11.85*** |
| **Health Behaviors** | | | | |
| BMI | -0.13*** | 0.07 | -0.01 | 0.12** |
| Alcohol Drinking | 0.74*** | 1.11 | -0.61 | -0.23 |
| Cigarette Smoking | | | | |
| Never smoked (Ref.) | | | | |
| Quitted smoking | -0.17 | -0.33 | -0.53 | -0.68 |
| Currently Smoking | -0.28 | -0.00 | -0.42 | -1.19* |
| **Oral Hygiene Behaviors** | | | | |
| Daily frequency of brushing teeth | | | | |
| 0-1 time (Ref.) | | | | |
| 2 times | 1.04*** | 2.68*** | 1.78*** | 3.54*** |
| ≧3 times | 1.16*** | 3.84*** | 2.39*** | 3.82*** |
| Using dental floss | | | | |
| No | | | | |
| Occasionally | -0.05 | 0.01 | -0.68 | 0.28 |
| Almost every day | 0.21 | 0.66 | -0.16 | 1.53*** |
| Using mouthwash | | | | |

**Table 5.7 The regression analyses for the sub-domains of physical health**

| | Physical Health | | | |
|---|---|---|---|---|
| | PF | RP | BP | GH |
| No (Ref.) | | | | |
| Occasionally | -0.39 | -1.14* | -0.48 | -0.23 |
| Almost every day | -0.21 | -2.35 | 0.56 | 0.51 |
| Having dental scaling every 6 months | -0.28 | -1.85*** | -0.62 | 1.18** |
| Dental visit in the last year | 0.33 | -0.10 | -1.05** | -1.17*** |
| **Self-Reported Oral Health** | | | | |
| Teeth lost | | | | |
| None (Ref.) | | | | |
| 1-8 | 0.20 | 0.40 | -0.15 | 0.85** |
| >=9 | 1.11 | 1.09 | 0.30 | 0.77 |
| Self-evaluation of dental function | | | | |
| Very bad (Ref.) | | | | |
| Bad | 1.45* | 1.68 | -1.29 | -2.40** |
| Fair | 1.38** | 2.56** | 0.62 | 0.51 |
| Good | 2.27*** | 4.48*** | 3.31** | 4.53*** |
| Very good | 2.26*** | 6.68*** | 4.33*** | 8.23*** |
| Self-limitation of food choices | | | | |
| Never (Ref.) | | | | |
| Occasionally | -1.25*** | -1.56** | -1.75*** | -3.31*** |
| Sometimes | -2.71*** | -7.82*** | -4.92*** | -5.39*** |
| Frequently | -5.69*** | -11.34*** | -7.31*** | -8.54*** |
| Always | -8.32*** | -22.76*** | -11.99*** | -13.21*** |

Note: PF=physical functioning; RP=role limitations due to physical health; BP=bodily pain; GH=general health;

Ref.=reference group

* P<.05, ** P<.01, *** P<.001

**Table 5.8 The regression analyses for the sub-domains of mental health**

| | Mental Health | | | |
|---|---|---|---|---|
| | VT | SF | RE | MH |
| **Demographics** | | | | |
| Age Group | | | | |
| 18~29 (Ref.) | | | | |
| 30~39 | 1.04*** | 0.89** | 2.47** | 0.97*** |
| 40~49 | 3.02*** | 1.97*** | 5.63*** | 3.98*** |
| 50~59 | 5.23*** | 3.58*** | 9.29*** | 6.68*** |
| 60~64 | 7.14*** | 4.94*** | 11.85*** | 9.55*** |
| Gender (Ref.=Female) | 4.50*** | 1.00*** | 1.34* | 2.97*** |
| Education | | | | |
| Illiterate (Ref.) | | | | |
| Junior high school or below | 5.02*** | 3.54*** | 1.34 | 5.81*** |
| Senior high school | 4.68*** | 2.98** | -0.06 | 5.85*** |
| Bachelor degree | 3.80** | 1.89 | -1.06 | 5.24*** |
| Graduate or higher | 2.04 | 3.24** | -2.00 | 5.83*** |
| Monthly Income | | | | |
| <5,000 (Ref.) | | | | |
| 5,000-20,000 | -0.45 | 1.95*** | 2.33* | 0.89** |
| 20,000-80,000 | 0.31 | 3.22*** | 5.56*** | 1.81*** |
| >80,000 | 2.61** | 3.70*** | 5.99*** | 1.31 |
| **Disease History** | | | | |
| Hypertension | -3.35*** | -2.02*** | -1.95* | -2.93*** |
| Diabetes | -2.18* | -1.72 | -0.93 | -0.93 |
| Hyperlipidemia | -2.85*** | -1.47** | -4.43*** | -1.71*** |
| Stroke | -8.53*** | -16.80*** | -16.27*** | -7.22*** |
| Asthma | -3.97*** | -3.55*** | -3.99* | -4.58*** |
| Kidney Disease | -3.97*** | -2.18** | -3.64** | -2.35** |
| Heart Disease | -6.42*** | -5.17*** | -9.36*** | -5.99*** |

**Table 5.8 The regression analyses for the sub-domains of mental health**

| | Mental Health | | | |
|---|---|---|---|---|
| | VT | SF | RE | MH |
| **Health Behaviors** | | | | |
| BMI | 0.27*** | 0.20*** | 0.25*** | 0.30*** |
| Alcohol Drinking | -0.58 | 0.05 | -2.14*** | -0.88** |
| Cigarette Smoking | | | | |
| Never smoked (Ref.) | | | | |
| Quitted smoking | 0.72 | -1.26 | 0.17 | 1.35** |
| Currently Smoking | -0.63 | -0.91** | -1.42** | -0.37 |
| **Oral Hygiene Behaviors** | | | | |
| Daily frequency of brushing teeth | | | | |
| 0-1 time (Ref.) | | | | |
| 2 times | 3.38*** | 1.52*** | 3.01*** | 2.93*** |
| ≧3 times | 5.00*** | 1.46*** | 3.48** | 3.68*** |
| Using dental floss | | | | |
| No | | | | |
| Occasionally | 0.67* | 0.15 | -0.99 | 0.55 |
| Almost every day | 2.08*** | 0.13 | 0.49 | 1.05** |
| Using mouthwash | | | | |
| No (Ref.) | | | | |
| Occasionally | -0.03 | -0.77** | -0.69 | -0.85** |
| Almost every day | 0.73 | -1.53* | -1.39 | 0.26 |
| Having dental scaling every 6 months | 0.54 | 0.19 | -0.12 | 0.67 |
| Dental visit in the last year | -1.31*** | -0.58* | -1.40** | -1.05*** |
| **Self-Reported Oral Health** | | | | |
| Teeth lost | | | | |
| None (Ref.) | | | | |
| 1-8 | 0.94** | 0.28 | 0.71 | 1.12*** |

**Table 5.8 The regression analyses for the sub-domains of mental health**

| | Mental Health | | | |
|---|---|---|---|---|
| | VT | SF | RE | MH |
| >=9 | 0.71 | 0.19 | 0.12 | 1.36 |
| Self-evaluation of dental function | | | | |
| Very bad (Ref.) | | | | |
| Bad | -1.65 | 0.60 | -0.97 | -1.10 |
| Fair | 1.20 | 1.50* | 1.38 | 0.99 |
| Good | 3.81*** | 2.65*** | 4.16** | 2.94** |
| Very good | 7.44*** | 4.16*** | 6.04*** | 5.81*** |
| Self-limitation of food choices | | | | |
| Never (Ref.) | | | | |
| Occasionally | -2.79*** | -2.53*** | -1.94* | -2.71*** |
| Sometimes | -5.15*** | -4.36*** | -7.92*** | -4.68*** |
| Frequently | -7.25*** | -6.91*** | -9.28*** | -5.61*** |
| Always | -11.00*** | -11.11*** | -18.53*** | -7.78*** |

Note:

VT=vitality; SF=social functioning; RE=role limitations due to emotional problems; MH=general mental health

Ref.=reference group

* P<.05, ** P<.01, *** P<.001

## 5.6 Regression Models of Adults' Teeth Lost

To examine the factors that would affect Taiwanese adults' teeth lost, we built a regression model and the results are shown in Table 5.9. When compared with the youngest age group, older age groups lost more teeth and the age group "60~64" was

associated with 2 teeth lost on average ( $\beta$ =1.97, p<0.001). Higher education levels and monthly income were significantly associated with fewer teeth lost. Those who had graduate or higher education lost 0.89 (p<0.01) fewer teeth than those with lower education. The disease histories, specifically hypertension, diabetes, and asthma, were significantly associated with increases in teeth lost ( $\beta$ =0.31, 0.86, and 0.42 respectively). Body mass index and alcohol drinking were not significantly associated with losing teeth. Current smoker had significantly more teeth lost than those who never smoked ( $\beta$ =0.52, p<0.001) suggesting that smoking is associated with bad dental condition.

Daily brushing of teeth twice had no significant association with teeth lost; however brushing more than 3 times was associated with more teeth lost ( $\beta$ =0.23, p<0.05) suggesting that excessive teeth brushing may be harmful rather than beneficial to the dental condition. Both using dental floss occasionally ( $\beta$ =-0.43, p<0.001) and almost every day ( $\beta$ =-0.50, p<0.001) were significantly associated with fewer teeth lost. Having dental scaling every six months reduced the number of teeth lost by 0.21 (p<0.01). Dental visit in the last year was also associated with fewer teeth lost ( $\beta$ =-0.16, p<0.01). Those with dental prosthesis had 0.16 increase in the number of teeth lost (p<0.001). Compared with very bad dental function, those who reported better dental function had fewer teeth lost. The number of teeth lost was also significantly associated with food choices. The adults who always limited their food choices had six more teeth lost compared with those who never had self-limitation of food choices ( $\beta$ =6.29, p<0.001).

**Table 5.9 Regression analysis for teeth lost**

| | $\beta$ | 95% C.I. |
|---|---|---|
| **Demographics** | | |
| Age Group | | |
| 18~29 (Ref.) | | |
| 30~39 | 0.20*** | (0.123 - 0.278) |
| 40~49 | 0.37*** | (0.238 - 0.498) |
| 50~59 | 1.17*** | (0.956 - 1.390) |
| 60~64 | 1.97*** | (1.373 - 2.561) |
| Gender (Ref.=Female) | -0.06 | (-0.212 - 0.083) |
| Education | | |
| Illiterate (Ref.) | | |
| Junior high school or below | -0.29 | (-1.019 - 0.446) |
| Senior high school | -0.67* | (-1.379 - 0.033) |
| Bachelor degree | -0.81** | (-1.530 - -0.080) |
| Graduate or higher | -0.89** | (-1.569 - -0.209) |
| Monthly Income | | |
| <5,000 (Ref.) | | |
| 5,000-20,000 | -0.13* | (-0.291 - 0.025) |
| 20,000-80,000 | -0.16** | (-0.318 - -0.006) |
| >80,000 | -0.30** | (-0.528 - -0.073) |
| **Disease History** | | |
| Hypertension | 0.31** | (0.007 - 0.606) |
| Diabetes | 0.86** | (0.217 - 1.495) |
| Hyperlipidemia | -0.23** | (-0.414 - -0.037) |
| Stroke | 1.04 | (-0.519 - 2.605) |
| Asthma | 0.42* | (-0.053 - 0.900) |
| Kidney Disease | -0.12 | (-0.460 - 0.220) |
| Heart Disease | -0.05 | (-0.586 - 0.492) |
| **Health Behaviors** | | |
| BMI | 0.00 | (-0.009 - 0.017) |

**Table 5.9 Regression analysis for teeth lost**

| | $\beta$ | 95% C.I. |
|---|---|---|
| Alcohol Drinking | 0.02 | (-0.082 - 0.113) |
| Cigarette Smoking | | |
| Never smoked (Ref.) | | |
| Quitted smoking | -0.01 | (-0.286 - 0.269) |
| Currently Smoking | 0.52*** | (0.356 - 0.688) |
| **Oral Hygiene Behaviors** | | |
| Daily frequency of brushing teeth | | |
| 0-1 time (Ref.) | | |
| 2 times | -0.08 | (-0.207 - 0.052) |
| ≧3 times | 0.23* | (-0.028 - 0.493) |
| Using dental floss | | |
| No | | |
| Occasionally | -0.43*** | (-0.522 - -0.347) |
| Almost every day | -0.50*** | (-0.624 - -0.381) |
| Using mouthwash | | |
| No (Ref.) | | |
| Occasionally | 0.01 | (-0.126 - 0.149) |
| Almost every day | 0.13 | (-0.198 - 0.459) |
| Having dental scaling every 6 months | -0.21** | (-0.387 - -0.031) |
| Dental visit in the last year | -0.16** | (-0.297 - -0.033) |
| **Self-Reported Oral Health** | | |
| With dental prosthesis | 0.16*** | (0.045 - 0.284) |
| Self-evaluation of dental function | | |
| Very bad (Ref.) | | |
| Bad | -0.79*** | (-1.360 - -0.220) |
| Fair | -1.53*** | (-2.046 - -1.011) |
| Good | -1.79*** | (-2.297 - -1.290) |

**Table 5.9 Regression analysis for teeth lost**

| | $\beta$ | 95% C.I. |
|---|---|---|
| Very good | -2.01*** | (-2.508 - -1.520) |
| Self-limitation of food choices | | |
| Never (Ref.) | | |
| Occasionally | 0.33*** | (0.095 - 0.567) |
| Sometimes | 1.35*** | (1.075 - 1.624) |
| Frequently | 3.34*** | (2.593 - 4.082) |
| Always | 6.29*** | (4.300 - 8.281) |

Note: 95% C.I.= 95% Confidence Interval
Ref.=reference group
* P<.05, ** P<.01, *** P<.001

# Chapter 6. DISCUSSION

The thesis has three study aims: 1) to identify current dental hygiene practice and dental health status among Taiwanese population; 2) to study the association between dental hygiene practice, dental health status, and quality of life indicators; and 3) to assess factors associated with tooth loss among Taiwanese population. The conceptual framework that provides guidance for accomplishing these three study aims was informed by a systematic literature review of the relevant topics. It consists of the outcomes of interest (which include quality of life indicators as measured by the eight SF-36 quality of life domains and loss of teeth among adults) and four groups of determinants: individuals' personal factors such as demographic, socioeconomic, and lifestyle behavioral characteristics, individuals' oral hygiene behavior, individuals' use of dental services, and individuals' self-assessed dental health status.

This chapter summarizes how the study aims are addressed through hypotheses testing, examines how these results compare with the literature, discusses the implications of these results for both policy and practice, identifies limitations of the study, and points towards future research priorities to continue this line of inquiry.

## 6.1 Results of Hypotheses Testing

Results of hypotheses testing are summarized in this section by presenting the key findings, under each study aim.

**Study Aim 1**: Identify current dental hygiene practice and dental health status among Taiwanese population.

**Research Question 1:** What is the current dental hygiene practice among Taiwanese

population?

This study included 16,634 Taiwanese adults, nearly one-third of whom were 18-29 years old. Most of the participants reported good behavior of brushing teeth at least twice a day, but they did not use dental floss, mouthwash, or have dental scaling very often. About 40% of the participants did not visit any dentist in the past year.

**Research Question 2:** What is the current dental health status among Taiwanese population?

As for their self-report oral health status, half of them reported dental prosthesis and 40% had teeth lost. Most of the participants reported very good, good or fair dental function and 70% never had to limit food choices because of poor dental function. However, a sizable of the respondents still reported their dental function as bad (14.9%) or very bad (2.9%).

**Study Aim 2**: Study the association between dental hygiene practice, dental health status, and quality of life indicators.

**Research Hypothesis 1:** There is a significant and positive association between dental hygiene practice and quality of life after controlling for known determinants of quality of life.

After controlling for known determinants of quality of life including personal factors, oral hygiene behavior, dental service utilization, and self-reported oral health, a significant and positive association was identified between the behavior of daily brushing teeth and all sub-domains of physical and mental health. A dental visit in the past year was found to be negatively associated with four subdomains of mental health, reflecting the need for the visit. In addition, using dental floss and having dental scaling were

positively associated with some of the subdomains of physical health and mental health such as general physical health, general mental health, and vitality. Using mouthwash was not a significant predictor.

**Research Hypothesis 2:** There is a significant and positive association between dental health status and quality of life after controlling for known determinants of quality of life.

Good or better dental function was positively associated with better physical and mental health than poor dental function. Also, more frequently reported limitations of food choices were associated with poorer physical and mental health. However, tooth loss was not found to be significantly associated with either physical or mental health. This could be due to the lack of knowledge of the timing of tooth loss. If tooth loss occurred in the past, it is unlikely to be associated with the current health status as the survey tries to measure.

**Study Aim 3**: Assess factors associated with tooth loss among Taiwanese population.

**Research Hypothesis 3:** There is a significant and positive association between dental hygiene practice and tooth loss after controlling for known determinants of tooth loss.

Significant and positive associations were identified between tooth loss and dental hygiene practice. Controlling for other factors, those who used dental floss, had dental scaling every six months, or had dental visit in the past year reported fewer number of tooth loss compared to those who did not have one or more of those dental hygiene behaviors.

**Research Hypothesis 4:** There is a significant and positive association between dental health status and tooth loss after controlling for known determinants of quality of

life.

Significant associations were identified between tooth loss and dental health status. Controlling for other factors, dental prosthesis and limitation of food choices were both positively associated with tooth loss, while dental function was negatively related to it.

### 6.2 Comparisons with Prior Research

The strong associations demonstrated in our study between dental health status and physical and mental health is consistent with many previous findings. However, contrary to previous studies (Ng and Leung 2006; Allen 2003), our study found that tooth loss was not significantly associated with mental or physical quality of life. This could be due to the nature of our study. Our measure of tooth loss could be a past event which is less likely to be associated with the current health status.

Our study also showed that socioeconomic factors including age, education and income, disease history and dental hygiene behaviors were significantly associated with oral health even when controlling for the behavioral factors and oral health status, which is consistent with previous studies. In general, those who were older, had lower education, earned less, or had diseases histories lost more teeth than others. Cigarette smoking was found related to tooth loss, but alcohol drinking was not, after controlling for other factors. This could be due to the corrosive nature of the nicotine within cigarettes which is harmful to teeth. This finding is different from the study of Klein et al. (2004) which demonstrated that heavy alcohol consumption was correlated with tooth loss. Although

our study did not differentiate among types of alcohol consumption, the finding may attest to the conclusion that risk factors for tooth loss may vary across populations (Copeland et al. 2004).

### 6.3 Implications of the Study

As the study indicates, oral health and oral health behaviors are important contributing factors to general health and quality of life, both physically and mentally. Therefore, policy makers and health providers should advocate for good oral health practice and ensure adequate access to oral health services for the population. Moreover, educational campaigns and other forms of oral health consulting should be in place to promote oral hygiene practice for better oral health, such as brushing teeth at least twice daily and smoking cessation.

In addition, policy-making regarding oral health should take full consideration of the socioeconomic determinants of health. Our study found that oral health disparities persisted, and poor oral health was more likely to be identified among people with low socioeconomic status or with more health needs. Additional resources should be allocated to this group in order to enhance oral health and quality of life of the public. It is possible that oral health serves as a marker of health disparities, for example, among race/ethnic

minorities (Edelstein 2012).

Below are concrete recommendations based on the above policy and practice implications of the study.

• Expand National Health Insurance coverage for dental visits particularly those related to preventive dental care.

• Integrate dental care into primary care by developing a seamless system of care delivery. Currently, dental care and primary care are two separate entities. This is based on our study findings that dental care is associated with general health and well-being.

• Enhance the educational function of dental hygiene by improving dental hygiene curriculum in elementary school, dental hygiene counseling at the primary care clinics as well as dental clinics, and incorporating dental hygiene education in regular public health campaigns.

• Provide targeted intervention to those mostly affected by the dental problem, namely, those of low socioeconomic groups.

### 6.4 Limitations and Strengths of the Study

This study has some limitations, including the use of a secondary database analysis, which takes the firsthand collection of data out of the hands of study investigators,

eliminating the advantages of direct contact with the study population. Also, the data provided in the secondary database was self-reported even though participants were also examined by dentists. The cross-sectional design of the study made it impossible to identify causal effects. Even though we interpret the significant factors as contributing factors to health, one could argue that the direction of influence could be reversed, i.e., good health promotes good dental practice. Additional study is needed to generate more definitive data and confirm that education and modification of lifestyle variables and dental hygiene practices could reduce tooth loss and improve oral health-related quality of life such as general physical health, general mental health, and vitality.

The major strength of the study is in its generalizability. A multi-stage stratified systematic sampling design was applied in the original National Health Interview Survey, allowing data to represent the national Taiwanese population. Results of the study can be generalized to the entire adult population of Taiwan as the weighted population characteristics are based on national population characteristics. Another major strength is in the subject under investigation. No research heretofore has examined dental health status, dental hygiene practice, and their association with quality of life and tooth loss. Results of the study could have both policy and practice implications.

## 6.5 Future Research

Future studies should continue investigating contributing factors to oral health and quality of life for different populations with different socioeconomic status in Taiwan so as to develop more targeted measures for specific populations and make resource allocation more effective and efficient. The current study controlled for socioeconomic status but did not conduct any stratified analyses so that our results are not specific in terms of which subpopulations are more vulnerable. Moreover, longitudinal studies and cohort studies should also be conducted to examine trend of oral health among Taiwanese adults and to establish causal relationships between contributing factors and oral health and between oral health and quality of life.

Another future research direction is to include an intervention component and examine its impact on improving dental hygiene practices. The intervention may take place in the most important sub-populations such as those of lower socioeconomic status population so that greatest impact can be achieved. If intervention is to be conducted, proper control groups must be included to allow valid generalization of study results.

Comparative research may also be conducted to see how the Taiwanese experience (such as dental practice and dental care) differs from that of other countries. Research may focus on determinants of dental hygiene practices and the efficacy of various

interventions that aim at improving dental hygiene practice. These comparative studies could further shed light on this line of inquiry and enhance the confidence in our findings. They can also help identify the best intervention or intervention components to be included or adapted to the Taiwanese context.

### 6.6 Conclusion

Results of this study not only provide the information on dental hygiene and dental health in Taiwan but also inform policy makers and the practice community of the risk factors associated with tooth loss. The study contributes to the literature regarding the current status of dental health and dental practice in Taiwan and the association between dental health and dental hygiene practice and quality of life and the general well-being.

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